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THE NATIONAL ESTUARINE POLLUTION STUDY

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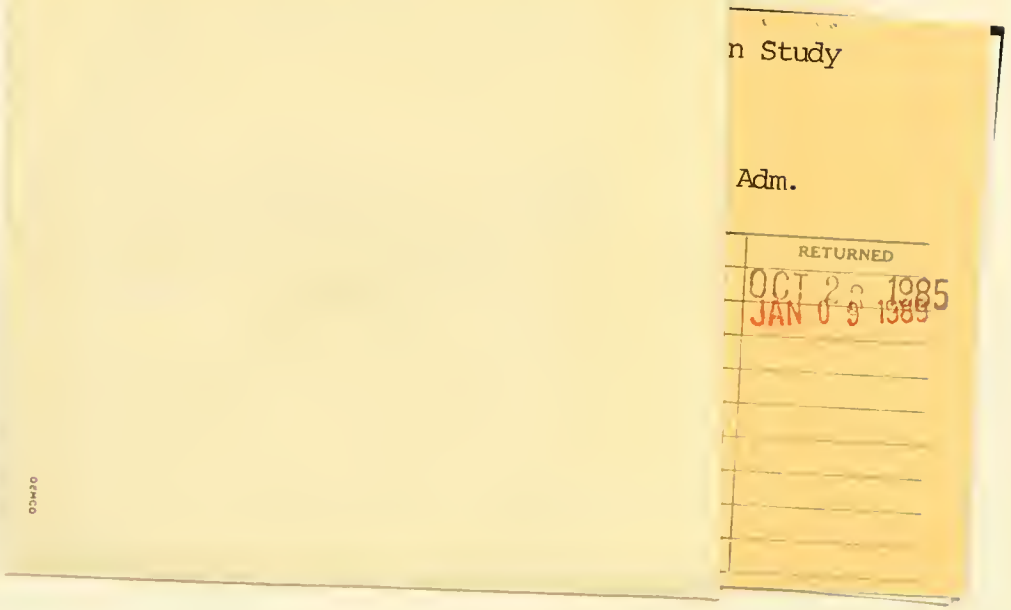
VOLUME I

U.S. DEPARTMENT OF THE INTERIOR

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION



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THE NATIONAL ESTUARINE POLLUTION STUDY

Volume I

A Report to the Congress

U. S. Department of the Interior • Federal Water Pollution Control Administration

NOVEMBER 3, 1969

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Part I
INTRODUCTION

This place without all question is the most pleasant and healthful place in all this country and most convenient for habitation . . .

It aboundeth with all manner of fish. The Indians in one night will catch thirty sturgeons in a place where the river is not above twelve fathoms broad. And as for deer, buffaloes, bears, turkeys, the woods do swarm with them, and the soil is exceedingly fertile.

From the Journal of Capt. Henry Fleete, the first white man to sail the Potomac River, Washington, D. C., 1632.

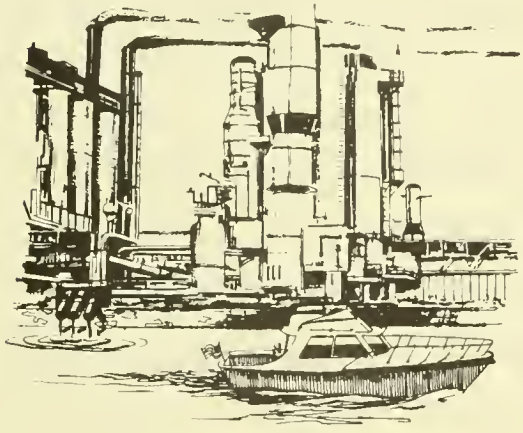
Man has had a long and intimate association with the sea. It has borne his commerce and brought food to his nets; its tides and storms have shaped the coast where his great cities have grown; the broad estuaries have provided safe harbors for his ships; and the rhythm of its tides has taught him the mathematics and science with which he now reaches for the stars.

Throughout recorded history the sea and its estuaries have been used as a limitless resource; now, however, the impact of man on his environment has taxed the resources of many estuarine zones to the limit of endurance and reached into the depths of the ocean itself.

For three hundred years the estuarine zones of this continent have provided the harbors through which a growing nation's commerce moved and around which great centers of population and industry developed. The fisheries of the estuaries and neighboring oceans yielded a variety of staple and exotic foods to feed the burgeoning population, while the adjacent farmlands benefited from equitable temperatures and seepage of water throughout the estuarine zones.

These three hundred years of unrestrained exploitation have seen the world of the estuarine zone evolve into three distinct but interacting environments.

There is first the natural ecosystem, a dynamic biophysical environment of land, water, and life, which follows a steady evolutionary pattern of its own, except when man has changed it. Its elements taken together comprise the total ecology of the estuary.



The second is the socio-economic environment, the user's world, a system of social and economic pressures directed toward exploitation of the natural environment, either by ignoring what happens to it, modifying it deliberately, or using it in its natural state.

Thirdly, there is the institutional environment. This is the realm of law, a system composed of those devices man has created in the form of law and organization to regulate his activities.

Increasing use and misuse of the Nation's estuaries have created and intensified many problems. Once productive shellfisheries have been completely smothered by sedimentation or closed by pollution; once deep and beautiful harbors are silted up and unnavigable, except for carefully marked dredged channels; passage of anadromous fish is blocked by polluted estuarine zones; thermal discharges affect entire ecosystems; diversion of rivers has caused salt water intrusion into ground water; and untreated or inadequately treated municipal and industrial waste discharges have damaged fisheries, added to siltation, and made many areas unsuitable for the increasing recreational use the present society demands.

There was little awareness of the danger to future generations as long as the ability of the natural environment to absorb the effects of the socio-economic environment seemed unlimited, and the problems of pollution and environmental damage were isolated. But now, in the second half of the 20th century, the entire Nation must face the results of those three hundred years of exploitation and weld the three estuarine environments into a national program to preserve, study, use, and develop the estuarine zone. Action is needed now. The purpose of this Study is to recommend that action.

THE STUDY DIRECTIVE

The Congress, in passing the Clean Water Restoration Act of 1966 (Public Law 89-753), Section 5(g), directed the Secretary of the Interior to study the problems surrounding pollution of the estuarine zone, and to make recommendations to the Congress for an effective national estuarine management program in which the Federal, State, and local governments, as well as public and private interests, will have clearly defined responsibilities.

The recommended program was to be based on a careful evaluation of existing relationships among the three estuarine environments; the effects of pollution on uses, and also the effects of demographic and use trends on pollution of the natural environment were to be considered.

All existing pertinent information was to be assembled, coordinated, and organized to serve as a factual base for the study, and additional investigations and surveys were to be carried out to supplement existing information. The study was to be conducted in cooperation with other Federal agencies, State and local governments, and other institutions and individuals. Everyone with an interest in the estuarine zone was to be consulted.

The report was to include not only the recommendations for a national program, but also an analysis of the importance of

estuaries in the economic and social environment and the effects of pollution on the natural ecosystem. A discussion of the major economic, social, and ecological trends was to show what the future might hold; and recommendations were to be made for research and study to acquire basic knowledge needed to manage future trends.

EXTENT OF THE ESTUARINE ZONE

The geographical scope of this study was stated in the Clean Water Restoration Act in this manner: " . . . the term 'estuarine zones' means an environmental system consisting of an estuary and those transitional areas which are consistently influenced or affected by water from an estuary such as, but not limited to, salt marshes, coastal and intertidal areas, bays, harbors, lagoons, inshore waters, and channels, and the term 'estuary' means all or part of the mouth of a navigable or interstate river or stream or other body of water having unimpaired natural connection with open sea and within which the sea water is measurably diluted with fresh water derived from land drainage."

Explicitly included in these definitions is all of the strip of land and water where the continent and the islands meet the sea, except those few stretches of coast where there

are no embayments and where there is no land runoff. Yet even these have already felt the impact of the expanding socio-economic environment, as the recent oil well blowout off Santa Barbara, Calif., demonstrated.

Implicit in the study directive is the charge to develop a program to protect the Nation's coastal land and water resources from the impact of pollution, and other disruptive pressures of the expanding social and economic environment, in the coastal region of the Nation. The investigations of this study and the recommendations presented in this report therefore include consideration of man's impact on the entire coastal environment, whether it occurs in a bay, or marsh, or along an ocean beach.

The term "estuarine zone", as used in this report, refers to the geographic zone including the coastal counties between the landward limit of tidal influence and the three-mile limit to seaward. Nevertheless, the true limits of the estuarine zone differ for each of the three major environmental systems that make up the estuarine environment. The dissimilarity between the definition and the actual zone of influence of the estuarine zone constitutes one of the major problems a national estuarine management program faces.

The natural estuarine environment extends from the landward limit

of tidal influence to the measurable seaward effect of fresh water runoff. This may vary in width from a few yards off some parts of the California coast to fifty miles off the Mississippi Delta.

The geographic range of the social and economic estuarine environment, the user's world, depends solely on man's ability and need to get to and use the estuarine environment. In terms of direct use, everything between the head of navigation landward and in sight of land seaward would be included.

The limits of the estuarine institutional environment are those of the political subdivisions that include parts of the estuarine zone. This includes the 274 coastal counties, the 24 coastal States, the Territories, the District of Columbia, a variety of interstate compacts and commissions, and the Federal Government.

The landward and seaward limits of the estuarine zone used in this study were set for the purposes of collecting and analyzing information pertinent to the study. The limits do not suggest that this zone can be isolated from either the upland rivers or the ocean, nor that this zone can be managed effectively without recognizing the problems in these and other environments.

THE NATIONAL ESTUARINE POLLUTION STUDY

The Congressional assignment to the Secretary of the Interior was delegated to the Federal Water Pollution Control Administration. The Administration established an Office of Estuarine Studies (now the Estuarine and Oceanographic Programs Branch) to carry out the study as directed by the Congress.

Immediate steps were taken to insure that all interested parties could participate actively. Representatives of each Bureau chief in the Department of the Interior formed an ad hoc Estuarine Advisory Committee, which was later formalized into an advisory group to the Office of Marine Resources. Each Federal Executive Department Head and each coastal State or Territorial Governor designated a representative to coordinate their participation. National scientific, cultural, and user organizations were invited to participate, and 30 public meetings were held throughout the estuarine zone to obtain the views of individual citizens. Numerous consultations were held with groups and individuals expressing interest:

All of these groups and individuals were asked to assist by providing information and opinion about the value, use, and pollution of the estuarine resource. The Federal Water Pollution Control Administration Regional Offices worked closely with State

agencies in collecting information, and other Federal agencies provided information collected by or through them. Some 22 contracts were negotiated to obtain particular types of information and to prepare case studies of specific estuarine systems. To organize and coordinate the vast amount of quantitative information, an automated information storage and retrieval system, the National Estuarine Inventory, was developed. The list of information to be included in the Inventory was developed with the cooperation of all Department of the Interior agencies and represents a consensus of what the Department regards as the basic information necessary for effective estuarine management.

The recommended national management program (Part III), probably the single most important result of the study, was reviewed at two stages by the coastal States and all concerned Federal agencies. The Department of Interior agencies have reviewed not only the recommended program, but also the discussions of supporting material leading to the recommended national program. (Parts II, IV, V, and VI).

ORGANIZATION OF THE REPORT

The report is organized to point out the relationship of the biophysical, socio-economic, and institutional environments

within the estuarine zone, and also to point out that technical management is a different matter from institutional management, even though there is a strong dependence between them.

Part II, "Summary and Conclusions," presents a summary of information (presented in more detail in Parts IV and VI) leading to the recommended national program.

Part III, "Recommendations--The Proposed Program," presents in full the recommendations for a comprehensive national program of estuarine management (presented in more detail in Part V), tying together the needs of the biophysical environment, the demands of the socio-economic environment, and the responsibilities of the institutional environment.

Part IV, "The Importance of the Estuarine Zone," discusses the biophysical and socio-economic environments of the estuarine zone, shows the interaction of the two environments, and points out how the demands of the one will affect the other if present trends in development continue without effective control by the institutional environment. The emphasis here is on technical management problems.

Part V, "Development of the Comprehensive National Program," discusses the institutional environment as it presently exists, shows the role each level of government plays, and points out what

role each should play to achieve effective management. The emphasis here is on institutional management problems in the estuarine zone.

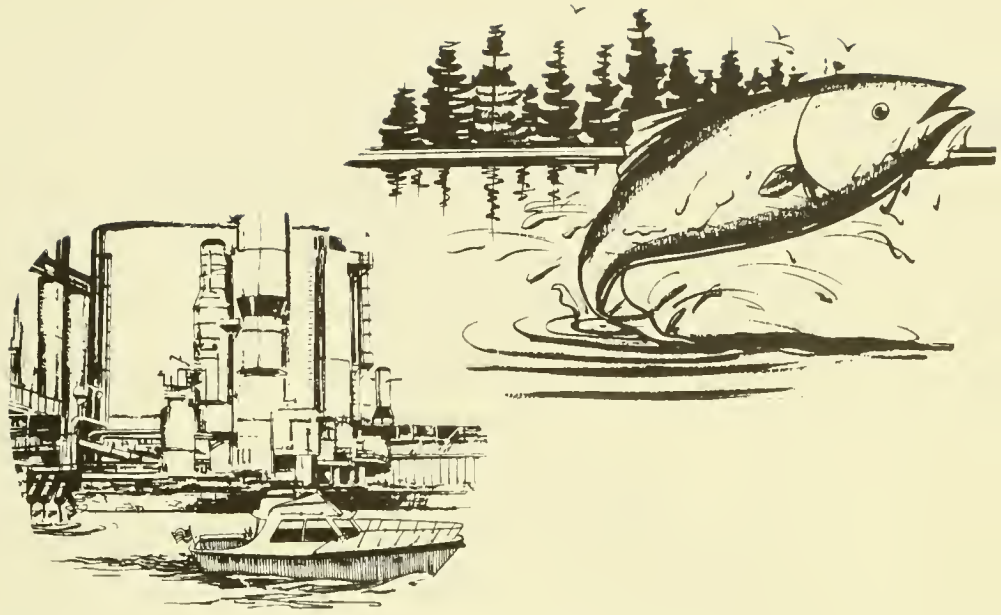
Part VI, "The Development of Data on the Estuarine Zone", discusses the present state of knowledge about all three of the major estuarine environments, and presents a program of studies and research efforts designed to close up knowledge gaps and provide the basis for sound technical management through rational institutional management.

Part VII, "Collection of Supporting Information", describes in general terms the mass of reference materials from which the information in this Report was derived. These materials consist of several thousands of documents, including transcripts of estuarine public meetings, profiles of Federal and State agencies, the Study's contractors' reports, and published reports in the scientific literature which relate to estuarine resources.

In-text citations to published material, referenced in the following volumes of this Report, are indicated by a number in parentheses, such as (V-1-1), which refers to the References list at the end of the appropriate chapter. Likewise, figures and tables are referred to in text by a number, such as Figure V.1.1, or Table V.1.1. Appendices follow the appropriate chapter.

In essence the report presents a technical analysis of the estuarine zone, identification of scientific knowledge gaps, and an inventory of the available knowledge, all of which form the basis for the recommended comprehensive management program for the Nation's estuarine resources.

This recommended national program is based on institutional management with multiple long-term use as a common denominator. Formation of the organizations to accomplish this and the active implementation of these recommendations will permit maximum use of the entire estuarine zone while preserving it for the benefit of future generations.



Part II

SUMMARY AND CONCLUSIONS

The estuarine zone is an ecosystem. That is, it is an environment of land, water, and air inhabited by plants and animals that have specific relationships to each other. This particular ecosystem is the interface between land and ocean, and one of its key components is human society.

The social and economic environment that forms human society must be regulated by man-made laws intended to provide justice to each individual and part of the socioeconomic environment. The biological and physical environment of the estuarine zone, in contrast, obeys natural laws which are equally complex and are less flexible than man-made laws. The welfare of American society now demands that man-made laws be extended to regulate the impact of man on the biophysical environment so that the national estuarine zone can be preserved, developed, and used for the continuing benefit of the citizens of the United States.

To apply man-made laws and regulations to the natural estuarine environment, it is necessary first to understand what natural conditions govern that environment, and then to understand how the socioeconomic and biophysical environments affect each other. Only then can there be developed an institutional environment which can effectively weld all three environments into one smoothly functioning self-sustaining ecosystem.

THE BIOPHYSICAL ENVIRONMENT

Laws regulating the socioeconomic environment exist at several levels of governmental authority. The Constitution presents general guiding principles, State constitutions operate within this framework while establishing a more detailed body of law designed to satisfy the needs of the statewide socioeconomic environment, and local ordinances regulate in detail the activities carried out in specific locations.

The biophysical environment is also subject to a hierarchy of laws, regulations, and conditions. The general guiding principles are those fundamental natural laws which govern all life on the earth; at the interfacial zone between land and sea the effects of these laws appear as universal dominating environmental factors. The structure of the coastline, formed and modified in obedience to these general conditions, imposes a second level of natural law which exerts its primary effects on water movement in the estuarine zone; and, within each structural form exists a host of organisms living according to specific natural ordinances which govern their relationships.

Dominating Environmental Factors

The natural estuarine environment is based on the conversion of radiant solar energy into other forms of energy with the assistance of the mechanical effects of gravitational energy. This conversion

is accomplished by an intricate array of prey--predator relationships among living organisms, from the microscopic living creatures which convert solar energy directly and are eaten by other organisms, to the fish and wildlife which are the ultimate life forms in the manless estuarine environment.

Solar radiation and gravitational forces control the natural environment through a complex series of mechanisms. In the estuarine zone this control exhibits itself through seven major environmental factors that exist throughout the estuarine zone.

(1) Continental Shelf. The submerged land next to the continent slopes gently to a depth of about 600 feet, then it drops more rapidly to form the deep ocean basins. This fringe of slightly sloping submerged land, which along much of the Atlantic and Gulf coasts would appear quite flat to the naked eye, is called the "continental shelf;" its width and general configuration along the U. S. coastline affects the force with which ocean waves strike the shore and consequently the manner and degree of shoreline erosion and accretion (Figure IV.1.1).

(2) Ocean Currents. The major ocean currents passing near or impinging on the continent exert strong, if subtle, effects on the estuarine zone through their temperatures, which affect continental land temperatures,

FIGURE IV.1.1 MAJOR OCEAN CURRENTS AFFECTING THE UNITED STATES

and through their nutrients, which govern the nature and productivity of offshore and estuarine fisheries. The cold Labrador Current water from Maine to Virginia, warm Gulf Stream water along the South Atlantic and Gulf coasts, and the California Current along the Pacific coast all have noticeable effects on coastal land and water (Figure IV.1.1).

(3) Coastline Slope. The configuration of the coastline itself, even though subject to additional molding by the flow of rivers to the sea, is closely related to the shape and structure of the continental shelf. A wide continental shelf is generally associated with lowland next to the coast, while a narrow shelf is associated with mountainous terrain. These associations throughout the estuarine zone of the United States have produced estuarine systems characteristic of particular regions. Glaciation in New England, Washington, and Alaska; old mountain ranges and a sedimentary coastal plain from New Jersey to Texas; and the young, steep ranges of the Pacific coast are all continental features having different impacts on the estuarine zone.

(4) River Flow. The estuarine zone is also shaped through erosion and sediment transport by fresh water making its way to the sea. All along the coastlines are streams and

rivers carrying water from land runoff to the sea. These waterways range from the Mississippi River, which drains 41 percent of the conterminous land mass of the United States, down to tiny trickles across a beach. The volumes of water and sediment moved reflect not only the total amount of precipitation and its annual cycle, but also the sizes and slopes of drainage basins and the types of soil over which the rivers flow.

(5) Sedimentation. The general outlines of many estuaries, lagoons, and embayments in the estuarine zone were formed by erosion from land runoff during the last ice age when sea levels were much lower than they are now. As the sea level rose, the drowned river mouths became zones of mixing, sediment deposition, and erosion where the rivers and tidal currents met. These erosion and sedimentation processes molded the estuarine zone into its present shape and continue to change it.

(6) Climate. Solar energy striking the earth sets up complex cycles of water and energy flow from the oceans to the sky and the land and back again. That part of the energy cycle occurring in the atmosphere gives rise to the various combinations of weather phenomena which make up local climates. Land, sea, and sky are mutually dependent in producing specific climates, and the great ocean cur-

rents play their indirect roles in modifying the climates of the estuarine zone.

(7) Tide. The tide stands alone as a controlling force and symbol of the estuarine environment. The combination of tidal action and river flow gives rise to that unique phenomenon called an "estuarine circulation pattern," which means the fresh water flows in one direction in one layer and the salt water flows in the opposite direction in another layer with various degrees of mixing at the interface between them. This type of circulation pattern is of great importance in some of the estuaries along the Atlantic and Gulf coasts, and to a large extent governs the capacity of such estuaries to rid themselves of waste materials.

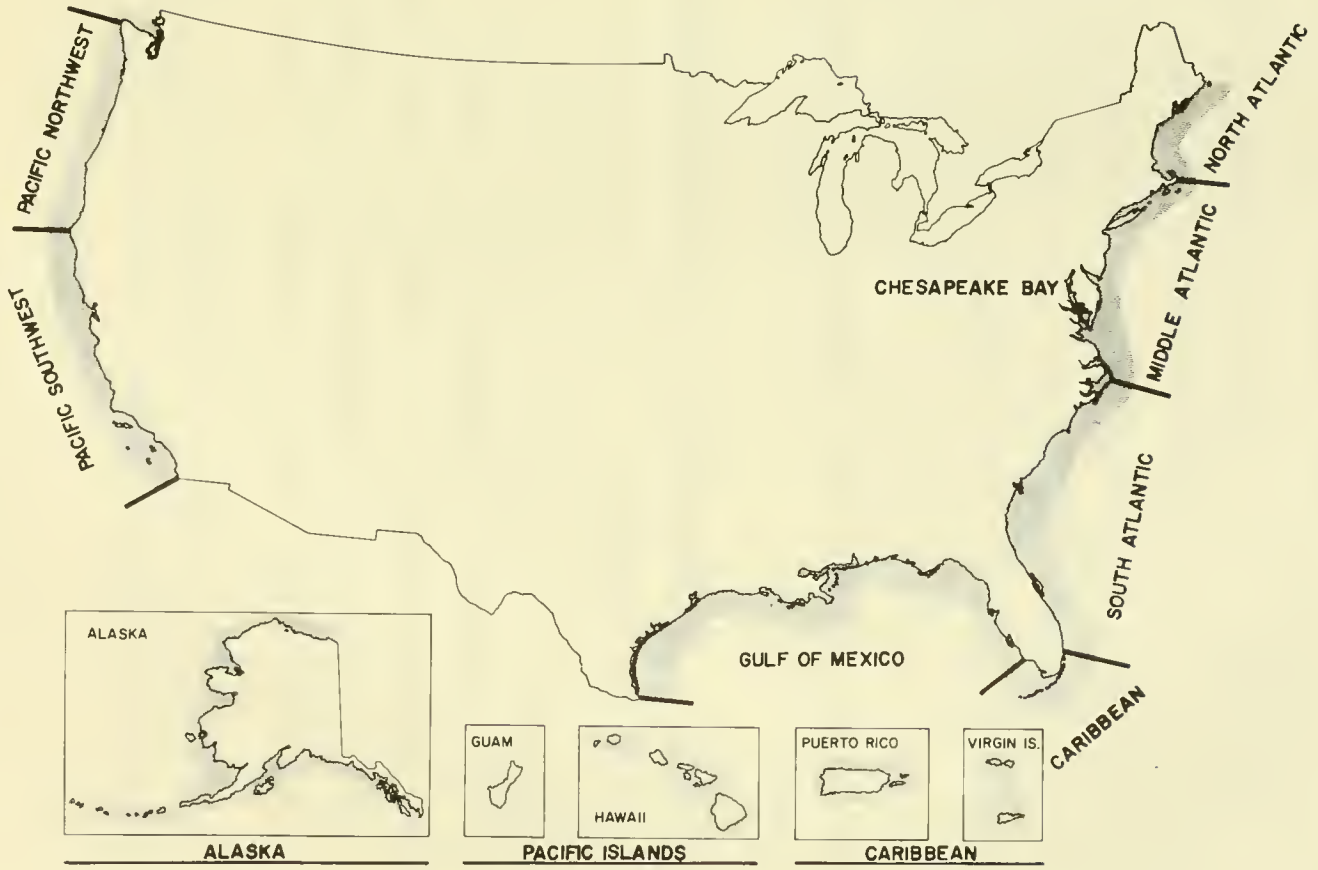
The Biophysical Estuarine Regions

Each estuarine system along the coastline is affected to some extent by all of these dominating environmental factors. In some cases the dominance of one particular factor is readily apparent. It is much more often the case that the competing environmental factors are so evenly balanced that none can be said to dominate and the estuarine zone appears to be composed of a bewildering variety of unique systems.

Yet, the dominating environmental factors listed above form a set of natural guiding principles which govern the general characteristics of the estuarine zone of the United States, and the occurrence of various combinations of these environmental factors permits the grouping of the national estuarine system into 10 geographical zones, each governed by a different combination of environmental conditions (Figure IV.1.19).

Figure IV.I.19

BIOPHYSICAL REGIONS OF THE UNITED STATES



Characteristics of the Biophysical Regions

North Atlantic Estuarine Region: Canadian border to Cape Cod.

Cool, fertile waters with a large tidal range strike a steep, indented coast with deep water close inshore, but protected from the full force of the ocean waves by a wide continental shelf. Moderate precipitation with heavy snowfall leads to heavy spring river runoff which dominates local circulation. Natural erosion and sedimentation are not severe problems, and the evolution of drowned river valley estuaries is in an early stage in this region.

Middle Atlantic Estuarine Region: Cape Cod to Cape Hatteras, exclusive of Chesapeake Bay.

A wide, gently sloping continental shelf with a smooth shoreline is cut by the entrances of several major river systems carrying moderate amounts of sediments. The same cool, fertile waters as in the North Atlantic estuarine region wash this coastline but with a smaller tidal range. The evolution of drowned river valleys into coastal marshes is in a secondary stage in the larger estuarine systems, with sand spits and barrier islands forming.

Chesapeake Bay Estuarine Region: All of the Chesapeake Bay system from Cape Charles and Cape Henry Island.

Isolation from direct oceanic effects in much of the greatly branched system, the many subsystems with major river flows, and the reduced concentration of the ocean salt throughout the Bay and its tributaries make this a unique estuarine system. This is a drowned river valley with numerous similar tributary systems in various stages of evolution.

South Atlantic Estuarine Region: Cape Hatteras to Fort Lauderdale, Florida,(about 26^{0} North Latitude).

The generally wide continental shelf is brushed by the warm waters of the well-defined Gulf Stream. The low-lying coastal plain terminates in barrier islands and marshes in which large amounts of sediments are being continually deposited by moderate-sized rivers fed by heavy summer rainfall. Many of the drowned river valley estuaries have evolved all the way to coastal marshes. Tidal ranges are small to moderate, depending on local conditions.

Carribean Estuarine Region: Fort Lauderdale to Cape Romano (the Florida peninsula south of 26^{0} North Latitude), plus Puerto Rico and the Virgin Islands.

High temperatures, heavy rainfall, and warm ocean currents along practically nonexistent continental shelves result in tropical

estuarine environments throughout this region. Coral reefs and mangrove swamps are the typical coastal features of south Florida, while the islands are mountainous and are fringed with coral reefs and beaches. Tidal ranges are small.

Gulf Coast Estuarine Region: Cape Romano to the Mexican border.

A wide continental shelf extends all the way around this large embayment, in which warm tropical waters are moved gently by weak currents and small tidal ranges. Heavy rainfall over most of the area brings sediments from the broad coastal plain to be deposited in the estuarine zone. Most of the drowned river valleys have evolved to a point intermediate between those of the Middle and South Atlantic Regions -- barrier islands are extensive and have large shallow bays behind them.

The Mississippi, carrying drainage from 41 percent of the conterminous land mass of the United States, forms one of the major deltas of the world and is unique among the estuarine systems of the United States, both in its size and in the extent to which it has built out over the continental shelf.

Pacific Southwest Estuarine Region: Mexican border to Cape Mendocino.

Because of the narrow continental shelf, periodic upwelling of deep water close inshore as winds force the California current offshore

brings cool, fertile water near the coast for several months of the year. The coastline has a typical beach and bluff configuration with only a few shallow embayments and the unique earthquake-born valley of San Francisco Bay, which, in the delta formed by the confluence of the San Joaquin and Sacramento Rivers, shows what erosion and sedimentation might have done along the southwest coast if rainfall were greater in that area of easily erodable mountains.

Pacific Northwest Estuarine Region: Cape Mendocino to the Canadian border.

The continental shelf and coastal configurations are similar to those of the Pacific Southwest, but ocean water temperatures are lower here; the movement of the California current away from the coast is not as pronounced, and heavier rainfall has resulted in some major rivers cutting through the coastal mountains to form deeply embayed estuarine systems. Extensive erosion and sedimentation have caused wide tidal flats, bars, and shoals to be typical of these systems.

The straits of Juan de Fuca and Puget Sound, which were glacier-formed, do not have as severe sedimentation as exists along the ocean coast, and have retained much of their original configuration.

Alaska Estuarine Region: All of Alaska including the Aleutian and Bering Sea Islands.

The dominant factors in this region are temperature and precipitation. Water temperatures are near freezing, and much of the precipitation falls as snow. The continental shelf is wide all through the region, and tide ranges are very large. The southeast and south coasts have active glaciation and consist primarily of glacier-cut embayments and fjords; the west and north coasts are much flatter and have been modified to some extent by sediments eroded from the interior, including glacial silt, and by the grinding action of pack ice during winter.

Pacific Islands Region: The Hawaiian Islands, American Samoa, and Guam.

This region consists of tropical ocean islands of volcanic origin. Dominating factors are lack of a continental shelf, full exposure to oceanic conditions, and pleasantly warm temperatures. Coral reefs and beach and bluff configurations are typical.

The Land and the Water

Within the general domination of broad-scale environmental factors are smaller scale governing conditions that, through their effects on water movement and circulation, determine what kind of local environment can exist in a particular estuarine system.

The Land

The shape of the land along the land-sea interface goes far toward determining what water movement and circulation patterns exist in particular local areas and, consequently, how fast a particular estuarine system will rid itself of pollutants. Within the general compass of the estuarine regions discussed in the preceding section there are different structural types which define patterns of water movement typical of particular structures, no matter what the external environment may be.

Alaska presents the greatest variety of estuarine form and structure of any of the estuarine regions. Nearly all kinds of systems typical of other regions are found there. In addition, Alaska has the only glaciated coast and most of the fjords found in the United States.

Characteristic of the North Atlantic region is a very irregular, hilly coastline with deep water close inshore and long, narrow embayments with open access to the sea. Estuarine systems within the Chesapeake Bay region consist of a group of branched rivers entering the Chesapeake Bay itself, which is in turn the former valley of the Susquehanna River.

In the Middle Atlantic region the estuarine zone consists primarily of a few large drowned river valley embayments (e.g., New York Harbor, Delaware Bay, Narragansett Bay) and some small marsh and

barrier beach systems receiving only coastal fresh-water runoff. The estuarine zone of the Gulf region, on the other hand, consists mainly of moderate-sized embayments with barrier beaches and extensive marshes, but receiving river flow from upland drainage areas and representing an intermediate state in the evolution of drowned river valleys into coastal marshes.

The South Atlantic region has two dominant types of estuarine structure. From Cape Hatteras to about Jacksonville, Florida, there is a general input of upland river drainage to the estuarine zone and the estuarine systems are typical drowned river valleys in the later stages of evolution represented by barrier beaches or coastal marshes backed by extensive swamps. South of Jacksonville fresh-water runoff comes primarily from local coastal drainage, and there are uniform and extensive barrier island beaches with long narrow embayments behind them having continuous but generally narrow strips of marsh along the embayments. This structure fades into the extensive swamplands of the Everglades farther down the Florida Peninsula.

Both the Pacific Northwest and Pacific Southwest regions have few estuaries. The estuarine systems of the Northwest Pacific Region tend to be the mouths of rivers which have cut their way through coastal mountain ranges, either of their own accord or aided by glaciers as in the case of Puget Sound. Shallow coastal embayments with little and sporadic river flow are characteristic of the few

estuarine systems of the Southwest, except for San Francisco Bay, which receives fresh water runoff from much of central California.

Estuarine systems of the islands, both Atlantic and Pacific, are few and consist mostly of embayments without major river inflows.

The estuarine zone can be classified according to its local morphology into ten major categories, several of which exist in each of the estuarine biophysical regions. Within each of these categories, the similarities in structure reflect similarities in water movement, water quality, and ecology which make it possible to apply lessons learned in managing an estuarine system in one region to similar estuarine systems in other regions. The morphological categories are:

1.1 Smooth shoreline without inlets

1.2 Smooth shoreline with inlets

1.3 Smooth shoreline with small embayments

2.1 Indented shoreline without islands

2.2 Indented shoreline with islands

3 Marshy shoreline

4 Unrestricted river entrance

5.1 Embayment with only coastal drainage

5.2 Embayment with continuous upland river inflow

6 Fjord

Unrestricted river entrances and embayments dominate the estuarine zone and are rather evenly distributed throughout all the regions, with the common type of estuarine system being a coastal embayment with drainage from only the local coastal area. Many of these latter embayments have large marsh areas, but the Middle Atlantic, South Atlantic, and Gulf are the regions in which marshes are the predominant feature in some parts of the estuarine zone.

The Water

The unique nature of water movement and circulation patterns in the estuarine zone are the result of the meeting and mixing of fresh river water and salty ocean water of slightly greater density under the oscillating influence of the tide. There may be additional complicating factors such as temperature and wind action, but the resulting circulation nearly always reflects the interaction of river flow and estuary shape with the tidal flow of the ocean water. General water movement patterns are predictable for each category of estuarine shape.

It is where moderately large rivers and streams meet the sea that the unique estuarine circulation patterns occur most frequently. Large fresh water flows in well-defined channels tend to slide over the top of the denser sea water without rapid mixing. Water movement in such cases exhibits various degrees of stratification.

With wider channels, smaller river flows, and greater tidal ranges

more mixing occurs and other forces come into play. Embayment shape, bottom configuration and material, and the effects of the Earth's rotation all may play a role. In some estuarine systems of this type, the degree of stratification may change with changes in river flow, temperature, wind, or other transient conditions.

Estuarine water quality is the product of both land and water. From the land, erosion and solution in river water bring suspended and dissolved minerals, while decaying vegetation adds dissolved salts, but negligible quantities of organic matter.

In the estuarine zone these two different solutions meet and mix. Salt concentrations range from that of the oceans to the almost unmeasurable amounts present in some rivers. Where little stratification exists, sea salt dominates mineral concentrations in estuarine waters; in stratified systems, however, the small amounts of minerals entering in the fresh water may be as important in some parts of the estuarine zone as the much larger concentrations from the sea are in others.

The Life

The governance of the dominating environmental factors, as modified by estuarine shape and water quality, result in an input of energy into individual estuarine systems, and it is in the variety and diversity of estuarine life that the input of energy to the estuarine zone finds ultimate expression. Whether

energy comes directly, as in solar radiation stimulating photosynthesis, or whether it comes indirectly, as with tidal flows or wind and rain pounding on the shoreline, its absorption and conversion to other forms of energy (such as food) are essential steps in the continuation of life in the water, in the marshes, and on the land.

Energy input from gravitational forces, as illustrated by tidal action and river flow, depends primarily on local or regional conditions, but direct energy input from solar radiation depends largely on latitude, the tropics receiving much more energy per acre than the arctic. The relative amounts of energy entering an estuarine system govern the kinds of life found there, and natural ecosystems show systematic variations related to the sources and amounts of energy received.

Estuarine zones with strong mechanical energy inputs from waves, currents, tides, or river flows develop similar ecosystems no matter whether in the tropics or the arctic. Where, however, such energy inputs do not dominate the input of radiant solar energy, natural communities develop compositions typical of Tropical, Temperate, or Artic latitudes.

Tropical systems are subject to unvarying warm temperatures; light energy input is both greater and more regular than in other latitudes. Within this general group there are the sparse populations along coasts with deep clear water close inshore; the

teeming and colorful populations of coral reefs; and the mangroves and the submerged grasslands associated with shallow, nutrient-laden water. Only the southern part of Florida and the islands are of this type.

Arctic systems are subject to wide fluctuations of sunlight and temperature but ice is the key factor. Ecological systems develop in, on, and under the ice and in the fjords associated with glaciers. Only a small part of Alaska includes estuarine systems of this type.

Temperate systems are subject to moderate solar energy inputs, temperatures which change regularly with the seasons, and generally larger tide ranges and more wave action than either tropic or arctic systems. Most of the estuarine systems of the United States lie in the temperate zone, and the balancing of solar energy input against mechanical energy input in this zone leads to a great variety of ecosystem types, even within small geographic areas.

The grouping of ecosystems outlined here describes a limited range of recurring variation of chemical and physical properties to which certain forms of life have adapted and on which they are now dependent.

The basic environmental needs for all living plants and animals in such zones are zones of salinity consistently fluctuating over a limited range of concentration; solar energy; water temperature variation; water quality and nutrients favorable to their

propagation, growth, and survival; and, for some life forms, bottom conditions suitable to their unique needs.

The dependence of fish and shellfish on the estuarine zone is governed by particular environmental requirements for reproduction, protection, food supply, or a combination of these. Estuarine dependent species are of three types:

1. Species Restricted to Estuaries

Among the relatively few species of fish and shellfish that complete their entire life cycle in the estuarine zone is the Atlantic (American) oyster. It will die after long exposure to freshwater although it can stand limited periods of such exposure and can thrive in relatively high salinity water. The spotted sea trout occupies the estuary for all its life purposes and only occasionally leaves the estuary under unusual extremes of salinity and temperature.

2. Anadromous and Catadromous Species

Anadromous species pass through the estuarine zone on their journey from the sea to the freshwater environment where they spawn. Some species, such as the Pacific salmon, die after spawning and others, such as the striped bass, live to return to the estuarine zone and the sea. The young of all anadromous species spend varying periods of time in the freshwater areas where

they were spawned, but all eventually migrate to the estuaries and then the sea.

There are few truly catadromous species that mature in the fresh or brackish water environments, and then migrate to higher salinity waters of the estuary of the adjacent sea to spawn. The American eel and the Blue crab are examples of this type.

3. Migratory Estuarine Species

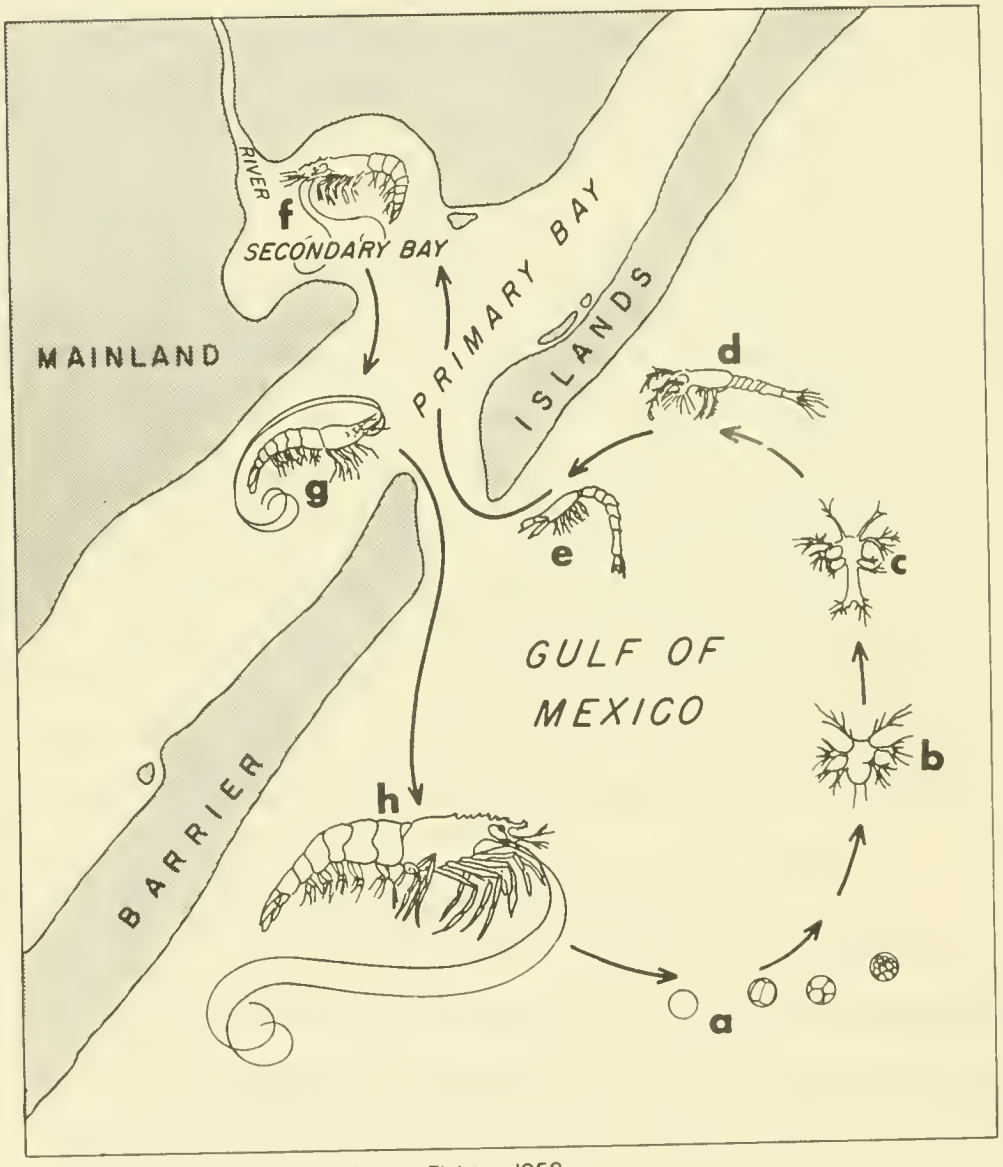
The great majority of estuarine dependent species fall under this classification. Some use the brackish and freshwater areas of the estuarine zone for reproduction; some as a source of food; some for shelter, either as adults or young; and some for all these reasons. They all have in common the basic need for both estuarine and ocean environments at some point in their life cycle. This group includes the great majority of fish and shellfish of direct importance to man, such as shrimp, menhaden, flounders, and red drum. (Figure IV. 1. 38)

Estuarine wildlife can be classified into four categories: (1) fur bearing animals, (2) game waterfowl, (3) ornamental shore birds, and (4) the common wildlife that can tolerate human presence.

The primary fur bearers are the fur seal in Alaska, nutria in the South Atlantic and Gulf States, the common eastern muskrat in

Figure IV.I.38

TYPICAL LIFE HISTORY
OF THE GULF OF MEXICO SHRIMP



Source W.C. Guest, The Texas Shrimp Fishery, 1958.

a Shrimp Eggs
b Nauplius Larva
c Protozoa
d Mysis
e Postmysis
f Juvenile Shrimp
g Adolescent Shrimp
h Adult Shrimp

New Jersey, the Virginia muskrat in the Central Atlantic States, and the Louisiana muskrat in Alabama, Mississippi, Louisiana, and Texas. Secondary in importance are the raccoon, mink, and otter.

The dependence of waterfowl on the estuarine zone is both complex and incompletely understood. The primary sport species, such as mallards and canvasbacks, have been successfully adapted to man-made changes in their environment, particularly those changes not affecting the nesting sites.

The ornamental shore and sea birds are a particularly aesthetic attraction among the national fauna. These birds are generally more dependent upon estuarine conditions than the more mobile waterfowl and, in addition, have demonstrated a considerably greater sensitivity to the overall encroachment of man. These birds include whooping cranes, pelicans, bald eagles, egrets, ibis, and many others.

Governing Subdivisions of The Biophysical Environment

Solar energy and gravitational energy are the basis for everything that happens naturally in the estuarine zone. This discussion of the biophysical environment has been concerned primarily with the environmental conditions surrounding the transformation of these energies into forms useful in living processes and exploitable by man. Three different sets of subdivisions of

the biophysical environment were used in this discussion.

Differences in the external environment divided the estuarine zone of the United States naturally into ten geographic regions, each subject to a particular governing combination of the external influences of tide, ocean currents, wave action, sedimentation, and climate. This subdivision into estuarine biophysical regions gave broad ranges of conditions in each region, but the importance of local coastal conditions in governing energy flows via water movement paved the way for a subdivision of the estuarine zone according to ten morphological groups having similarities in water movement, circulation, and the ability to rid themselves of wastes.

A subdivision according to ecological communities was also based primarily on geographical location, but again coastal conditions made it necessary to identify small ecosystems governed by specific local conditions within each of the major groupings.

THE SOCIOECONOMIC ENVIRONMENT

The socioeconomic environment of the estuarine zone is the direct result of its value as a means of sustenance, a place to live, a source of enjoyment, and a route of transportation. The laws regulating man's activities in this zone are historically intended to protect and serve individual and group interest in dealing with each other. Only recently has it become apparent that the laws protecting man from himself must be extended to protect the natural environment from man.

This extension of the institutional environment must recognize not only the realities of how the biophysical environment operates, but it must also recognize the need of human society for the estuarine zone and its value to civilization both as an essential part of his ecosystem and as an exploitable resource.

Population and Industrial Development in the Estuarine Zone

The importance of the estuarine zone of the United States to the national community is shown most clearly by the numbers of people that use it. Population concentration in the coastal counties began when the first European colonist arrived. This concentration brought about the development of a corresponding amount of manufacturing industry in the estuarine zone, while the great harbors gave the estuarine zone its dominating position as the commercial center of the Nation.

Long before the settlement of Plymouth, British, French, and Spanish fishermen were exploring the North Atlantic fishery resources including those in the Gulf of Maine and along Georges Bank; after colonization of New England, the fisheries were the sustaining industry that provided the economic foundation for growth and development. The estuaries were also the entry portal for the immigrants that came to this Nation looking for the land of opportunity.

As the population grew, the relative importance of the fishery progressively declined as economic growth in other industries outstripped the demand for seafood as a staple diet item. The growth of industrial and population centers in the estuarine zone closely paralleled the growth of the rest of the Nation, with the estuarine zone becoming relatively more important in international commerce and less important in agricultural food production than the interior of the country.

The coastal counties contain only 15 percent of the land area of the United States, but within this area is concentrated 33 percent of the Nation's population, with about four-fifths of it living in primarily urban areas which form about ten percent of the total estuarine zone area. Another 13 percent of the estuarine land area is farmland, but this accounts for only four percent of the total agricultural land of the Nation. The estuarine zone, then, is nearly twice as densely populated as the rest of the

country, and supports only one-fourth as much agriculture per unit area.

In those regions lying between Cape Hatteras, N.C., and Canada as well as in the Pacific Southwest, over 90 percent of the population lives in urban areas; over much of the Atlantic estuarine zone stretches the great northeastern megalopolis with population densities averaging over 1,000 persons per square mile. The remainder of the estuarine zone of the United States exhibits a pattern of major centers of population clustered around natural harbors and separated by stretches of coastline which are either empty and inaccessible or beginning to be sprinkled with private residences and resort communities in the vicinities of population centers.

The coastal counties have within their borders 40 percent of all manufacturing plants in the United States. The mixture of manufacturing types in the estuarine zone is the same as the national composition with only minor exceptions, such as the concentration of the apparel manufacturing industry in the Middle Atlantic region, particularly in the New York area. Distribution of manufacturing types among the biophysical regions shows regional differences related to historical development as well as raw material and market availability.

Over half of all plants in the coastal counties and one-fifth of all manufacturing plants in the United States are located in the Middle Atlantic biophysical region, which was the historical center of the

of the Nation's industrial growth and is still one of the major market areas. The Pacific Southwest is the major industrial center of the Pacific coast and is developed as intensively as the Middle Atlantic region. Some industrial development in other regions tends to follow historical or present raw material availability. Leather product plants are clustered in the North Atlantic region, and lumber manufacturing plants are most plentiful in the Pacific Northwest. Food processing plants, however, follow closely the distribution of population.

While much of the industrial development located in coastal counties affects the estuarine zone indirectly through use of adjacent land, some of the water-using industries have an impact on the estuarine zone far beyond their numbers. The paper, chemical, petroleum, and primary metals industries are the major water users among manufacturing establishments and are distributed universally throughout the estuarine zone.

Use of the Estuarine Zone

Many of the uses catalogued in this report occur only because the historical growth of the country makes the estuarine zone the place where the people and the industry are. Only commercial navigation and commercial fishing are uses which are primarily associated with the estuarine zone rather than other parts of man's environment. Uses such as water supply, waste disposal, and recreation are

associated with civilization wherever it exists; in the estuarine zone they may have different values, different emphasis, or different impact on the biophysical environment.

The great unique use of the estuarine zone, which makes it of primary importance to man and his civilization, is its place in the life cycle of many animals which aid in converting solar energy into more usable forms. While no life form can be singled out as irreplaceable, the kinds of life which need the estuarine zone to survive represent essential links in the energy conversion chain upon which man depends for survival. Many of the human uses of the estuarine zone depend directly or indirectly on the existence of the estuarine zone as a healthy habitat.

Fishing

The important fish species are those sought by either the sports fisherman or the commercial fisherman. Practically all of the sports fish species are dependent upon the estuarine zone for one or more phases of their life development, and approximately 65 percent of all commercial fish species are estuarine-dependent.

In 1967 United States fishermen received $438 million dollars for approximately 4.06 billion pounds of commercial fish and shellfish. It has been estimated that two-thirds of the total value, or approximately $300 million dollars, can be considered for estuarine-dependent species. This is a conservative estimate of the direct

value derived from the estuarine fishery for it does not include the value of fish harvested by foreign vessels off the United States coast. Five of the six leading species by weight, representing over one-half of the United States commercial fish tonnage in 1967, are estuarine-dependent.

Recreation

The demand for outdoor recreation has increased significantly over the past decade. The trend toward higher personal income and more leisure time has made it possible for a greater percentage of the populace to seek new outlets. Companies manufacturing equipment for outdoor recreation have sprung up by the hundreds.

The advertising industry has campaigned vigorously to sell the public on the need for recreation, and service facilities to support the recreationalist are blossoming in all parts of the country.

There are a wide variety of land and water recreational activities available in the estuarine zone and many estuarine systems are intensively used for recreational pursuits. The unique combination of available resources in close proximity to large population centers offers an unparalleled recreational opportunity for many people who could not afford to travel far from their homes.

Each type of recreational activity has a certain sensitivity to the quality of the environment in which the activity takes place.

Clusters of activities that require similar environmental conditions but differ in environmental quality needs can be grouped as follows: 1) swimming and associated shore activities, including picnicing and camping; 2) sports fishing from shore or small boat; 3) boat-centered activities, such as cruising or water skiing; and 4) aesthetic appreciation of the total environment.

Transportation and National Defense

The Nation's estuaries provide the physical, social, and economic conditions required for an effective system of water terminals serving international trade and coastal shipping. According to a 1966 inventory of ports and terminals by the Maritime Administration, there were 1,626 marine terminal facilities providing deep water berths in 132 ports on the Atlantic, Gulf, and Pacific coasts. The significance of these ports and terminal facilities is indicated by the 1965 statistics which show that these ports handled 346,315,000 tons of foreign trade cargo which was 78 percent of the U.S. foreign trade total. In addition, the port facilities handled 332.1 million tons in coastal cargo and 288.2 million tons in local shipping.

The estuarine ports also serve as essential elements of the national defense system. The deep water terminals exert a significant influence on the location of defense installations as well as of the industrial complexes necessary for logistical support of the defense effort. A direct indication of the use of estuaries by naval vessels

is the total number of ships in commission. During the Fiscal Year 1967 this number was 931 with a planned increase to 960 in the Fiscal Year 1969.

The use of the harbors for waterborne transportation is competitive in that it may cause other uses to be foregone. Heavy ship traffic interferes with pleasure boating and related activities. Maintenance of the ship channels may alter the ecology and the surface area occupied by the large vessels may well interfere with safe pleasure boating.

Water transportation is not the only type of transportation consideration for estuaries. Since a major percentage of large cities are located on estuarine systems, there is considerable pressure to develop fill areas for airports which then utilize the long overwater approaches to keep the jet noise away from developed areas. The water areas offer a barrier to land travel that must be overcome with causeways or bridge type structures which can interfere with navigation or cause habitat damage. On the other hand, peripheral roads offer some of the more scenic routes available and are frequently the only undeveloped area on which roads can be built.

Municipal and Industrial Water Supply

The water in the estuary can serve as a source of both domestic and industrial water supply; but utilization of estuarine water for domestic supply is very limited at the present time. Normally the

brackish water is unpotable and treatment costs to render it potable are extremely high. The brackish estuarine water is also a poor source for industrial process water. Here again a high degree of purity is normally required in the process water and the cost of removing the dissolved salts is prohibitive.

Estuarine waters are used extensively, however, as a source of industrial cooling water. For this use the most important considerations are the quantity and the ambient temperature. Water temperatures are generally well below the maximum for economical cooling, and since the ocean is connected to one side of the estuary, the quantity is no problem. Cooling water is required by both the manufacturing industry and electric power generation plants; the greatest use is in the thermal electric plants.

The distribution of cooling water use parallels population and industrial development in the coastal counties, even though electrical power can be transported economically over many miles. The greatest concentrations of cooling water use are in the Middle Atlantic and Pacific Southwest Regions; fortunately these regions both have moderate water temperatures which make possible efficient use of the available cooling water.

There are, however, 47 nuclear power plants built or scheduled for completion by 1976. All of these are in the megawatt range, with a combined capacity of nearly 35,000 megawatts of electrical power.

While the bulk of these will be in the cooler parts of the Nation, 12 will be in the South Atlantic, Gulf, and Caribbean Regions where water temperatures are high, greater volumes must be used to achieve proper cooling, and the increase in water temperature through the power plant may be sufficient to cause environmental damage.

Waste Disposal

The concentration of population and industrial development in the estuarine zone has led naturally to the use of estuarine waters for removal of the waste materials of man's civilization from his immediate vicinity. It is unlikely that cities were built on the coastline with any conscious consideration of the use of the estuarine environment for waste disposal, yet it has happened that this use has become one of the major uses of estuarine waters and the associated land. Virtually all of the cities and industries in the coastal counties dispose of wastes either directly or indirectly into the estuarine zone.

Liquid waste discharges to estuarine systems include domestic waste products, industrial waste materials of all degrees of chemical complexity and sophistication, used cooling water with its thermal load, and storm runoff. These wastes affect the estuarine environment in different ways and can eliminate other uses.

Liquid wastes are not the only concern. The use of the estuarine shoreline for refuse dumps and land fills results in considerable

debris getting into the water; water leaching through these dumps has a pollutional impact on the estuarine water. Spoil disposal from dredging activities is another form of solid waste material that contributes to estuarine degradation, and solid materials entering the estuary in the form of debris from storm runoff can be significant in terms of damaging beneficial uses.

Waste disposal is a highly significant and universal use of the estuarine resource and it is likely to remain so. Along with the many other socioeconomic uses of the estuarine environment, it must be managed so that it does not damage the biophysical environment.

Exploitation of Mineral Resources

Minerals within the water, on the bottom, and under the bottom are a valuable part of the estuarine resource and are being exploited widely.

Sub-bottom mining operations are limited to the recovery of sulfur, petroleum, and natural gas, with the major operations occurring in Louisiana, Texas, California, and Alaska. These operations exist both in the estuaries and out on the continental shelves with the governing criterion for locating being the location of reserves.

Recovery of minerals from submerged estuarine zone bottoms by surface mining, i.e., dredging, is primarily directed toward sand, gravel, and oyster shell production. Sand and gravel operations are

universal throughout coastal areas wherever suitable deposits and a market exist.

Oyster shell is an extremely useful construction material in the Gulf of Mexico biophysical region. Twenty of the twenty-two million tons of annual U.S. production are in the Gulf States with Texas and Louisiana producing the vast majority of it.

Phosphate rock is an important estuarine mineral resource; about 75 percent of the total U.S. production is in the estuarine zone of Florida and North Carolina, particularly around Tampa Bay and Pamlico Sound.

Aquaculture

The great fish and shellfish resources of United States coastal waters have adequately supplied the seafood demands of the increasing population for over three hundred years. Now, however, the demands for some products is so great that the normal fishing grounds and fisheries are in great danger of being exhausted, both from overfishing and from the indirect effects of man's encroachment into the estuarine environment. To supply future needs of some fish products new approaches toward commercial fishing are needed, both in harvesting the natural growth and in controlling the entire fishery. Aquaculture is defined as the rearing of aquatic organisms, both plants and animals, under controlled conditions using the techniques of plant and animal husbandry. It involves a variety of operations, some

that are highly sophisticated where man exercises control over the principal environmental factors affecting the cultured species, and others that are very simple with only minimal control or manipulation of the habitat and the cultured animal.

Shoreline Development

The use or development of estuarine water either governs or depends on land or shoreline use.

Commercial development of the shoreline includes loading terminals, docks and shipyards, airports, industrial plants, and the smaller municipal and local piers. Recreational facilities include marinas, beaches, parks, fishing piers, and vacation cottages, motels and hotels. Although the motels and hotels are a commercial venture, their prime purpose is to support the recreationist. Residential development of waterfront property in many communities places on the shoreline intensive housing development accompanied by boat docks, fishing and swimming piers, and private beaches. Commercial and personal transportation requires airports, highways, and commercial port facilities.

Structures built to protect or conserve the shoreline include bulkheads to hold the shore in place, dikes to prevent flooding and to extend reclaimed land, jetties to provide a protective barrier between the sea and ship channels, and groins along beach areas to control sand movement.

The Social and Economic Values of Estuarine Use

All uses have value, both individually and as part of the development and use of the entire estuarine resource for the benefit of the present and future national community. The importance and total value of any estuarine system lie not in the measure of economic value for any particular use, but in multiplicity of use related to the needs of people who live there or otherwise depend on the estuarine resource.

Fish and Wildlife Habitat

The value of the estuarine zone as fish and wildlife habitat both depends on and augments its value for other uses, particularly recreation and commercial fishing.

There is, in addition to these, the basic incalculable value of the estuarine habitat as a link in the essential energy-conversion chain which permits man to survive at all.

The trapping of fur bearers in the marshes of the Gulf and Atlantic represents one of the few economic values directly attributable to estuarine habitat. Louisiana is the major producer; in the 1965-1966 season total sales were 4.6 million dollars out of the Nation's 6 million-dollar total.

Commercial Fishing

An entire complex of commerce and industry can rest upon one primary producing industry such as commercial fishing. Each time the basic product changes hands it generates economic activity and gains in value until by the time it reaches the ultimate consumer, its price may be many times what the fisherman was paid for it. The effect of such "value multiplier" factors will be such as to make the actual values of specific commercial fisheries several times the landed values.

Thus, the 438 million dollars received by United States fishermen in 1967 probably represents a total input to estuarine zone economic activity of over one billion dollars; exactly how much it is impossible to say. Case studies assign multiplier values of about three and four to commercial fishery landing values, but the magnitudes of such multipliers depend on the structure of the local economy as well as on other factors and generalities are likely to be misleading.

The relationship of the estuarine zone and commercial fishing cannot be expressed by any simple economic index. The importance of commercial fishing in the estuarine zone is related economically not only to estuarine habitat, but also to transportation, commerce, food processing, and aquaculture.

Recreation

Each kind of recreational use has its own economic impact. Recreational boating supports a large boatbuilding, marina, and boat repair industry. Sport fishing supports not only a certain part of the boating industries, but also a very specialized industry manufacturing and selling fishing tackle. For example, the 1965 Survey of Fishing and Hunting shows that salt-water anglers spent $800 million dollars in that year. Sightseeing and swimming support motel and restaurant services in the favored areas, as do other overnight recreational activities.

Attempts at the quantification of overall recreational economic values are not yet well-developed. The user-day recreation benefits approach has been used in some federal waterway and reservoir projects, but has been used in the estuarine system only in an analysis of fisheries and recreation in San Francisco Bay. Net benefits for general recreation activities, by this method, range from $0.50 to $1.50 per day. Specific forms of recreation may have higher values.

Applying such a figure to the population of the coastal counties suggests that the value of the recreational resource of the estuarine zone is about 300 million dollars if each person has about five days of recreational use. Such an estimate would include only local use and no multiplier values and might therefore be regarded as minimum value of the entire value of the entire estuarine recreation resource.

The major problems in defining the economic values of recreation in the estuarine zone lie in the facts that recreation itself is not an easily defined commodity nor can it be isolated from other economic activities such as transportation, food and lodging services, and equipment manufacturing.

Commercial Navigation and National Defense

Estimates of the economic value of commercial navigation are based on the direct revenue to the port of handling a ton of cargo, generally $16 to $20. Such estimates lead to a total value of the estuarine resource of $4.7 billion annually for cargo revenues alone, without multiplier values. An additional economic value of $10 billion annually in salaries and wages has been estimated for eleven major ports.

These estimates do not show the impact of commercial navigation on land transportation, shoreline development, or the manufacturing industries. Without the deep, safe harbors commercial navigation could not exist on a large scale, and without commercial navigation the great cities around these harbors would not have developed.

Deep-water harbors are essential elements of the national defense system. Furthermore, the location of these deep-water ports has influenced the location of other defense installations as well as the industrial complexes necessary for the logistical support of the defense effort.

The cost of the national defense effort in the estuarine zone for 1967 is estimated at about $900 million, exclusive of pay and allowances for shore-based Navy and Marine Corps personnel. The economic impact of national defense activity overlaps into all other estuarine zone uses because of the massive payrolls associated with it. This impact is centered in the areas with major defense installations.

Waste Disposal

The waters of the estuarine zone have received wastes from the people and industries on their shores ever since the first cities were founded. The economic benefit in the use of estuarine waters for waste disposal has been fully utilized by nearly all industries and communities in the estuarine zone, and only the tremendous capacity of estuarine waters to absorb and remove waste materials has kept the estuarine zone from suffering severe damage from such waste discharges.

No overall estimate of the value of this use of the estuarine resource is possible because the level of treatment necessary in any particular case depends on many local factors.

While the use of estuarine waters for waste disposal may not be aesthetically appealing it is an existing estuarine use with which other uses must compete, and it should be considered along with them in the overall economic evaluation of estuarine uses.

Examples of Socioeconomic Environments in the Estuarine Zone

Almost all estuarine systems have either a multiplicity of uses at the present time or such uses are available in the system. Estuaries presently support such varied uses as military berthing and associated activities, commercial port facilities, shipping channels, industrial uses, commercial fisheries, sport fishing, recreation, wildlife habitat, and purely aesthetic purposes. In most estuaries one or two of the uses predominate while the others take minor roles.

Narragansett Bay is an ideal example of an estuary that has developed in an unbalanced fashion. That is, the economic value of the estuary at the present time is largely associated with the industrial, military, and transportation uses of its waters. Other uses are, of course, made of the estuary but their economic significance is dwarfed by the tremendous magnitude of the military and commercial uses. However, it must be remembered that this economic measure is merely an indicator of the value of the waters and is not in any way related to the right or necessity of polluting such waters in the process of achieving this value. In fact, the only time that such an economic measure would be used would be for comparing one total use of the estuary to another total use. Of course, it is seldom that questions are so broad as to cover either/or propositions for the entire activity. Rather, the questions usually revolve around such things as the benefits to be derived from reducing pollution caused by users of the estuary compared with the costs of achieving the reduction in pollution.

Franklin County, Florida, is dependent upon pollution-free waters in Apalachicola Bay for its economic existence. The unpolluted waters of the Bay provide the seafood caught by local commercial fishermen and processed at shore-based installations. Additional income for the area results from tourism engendered by the Bay's waters.

Both tourism and commercial fishing are prime potential sources of income to any estuarine system. In the case of Apalachicola Bay, these happen to be the major sources of income because of the nature of the estuary and its location which prevent its development as a commercial shipping facility.

The San Diego economy, although heavily dependent upon the military and shipping activities in the Bay, has diversified to the exte that it is no longer completely dependent upon such uses of the Bay. At the same time there has been a growing demand for recreational uses of the Bay. Evidence of the local resident's interest in the Bay for recreation, tourism, and commercial uses can be found in their willingness to invest substantial sums of money in facilities to prevent pollution of the Bay by municipal wastes.

Mission Bay, a separate estuary in the San Diego area, is an example of the recreational potential to be found in an estuarine system. However, this special study points up the fact that the best use of an estuary may not come about naturally. Rather, it shows that a planned

development program with adequate investments are necessary to achieve optimal use of an estuary.

Measures of Overall Value and Importance

The discussions of values of individual uses and the case studies of specific estuarine systems present a confusing picture of the relationship of estuarine uses to economic indicators.

Estimates of the direct gross economic benefit of the estuarine zone to the residents of the coastal counties can be made. The estimates of economic activity generated by the presence of Narragansett Bay in Rhode Island give a conservative annual economic benefit of $920 per capita, $420 of which is personal income. Average personal income for all of the coastal counties is, according to Bureau of the Census figures, $500 per capita greater than the average for the remainder of the country. The total economic activity generated by this additional personal income then amounts to about $1,100 per person, using the Narragansett Bay multiplier values.

The total direct economic benefit of the estuarine zone to the residents of the coastal counties is then about 60 billion dollars in terms of additional economic activity stimulated by the presence of estuarine systems. This is not a measure of the total economic activity of the estuarine zone, but only of the "value added" to the total economic activity of the coastal counties by the presence of the estuarine zone.

Such gross means can give only an order-of-magnitude estimate of even the direct economic value of the estuarine zone and cannot possibly reflect either indirect benefits or the social importance of the estuarine zone, much less its ecological value.

Valid criteria for evaluating the importance of the estuarine environment or the value of individual estuarine uses, to a community must, however, go beyond the reach of economic approximation and recognize the fundamental relationship between man and his environment. Wherever there are people the environment will be exploited to satisfy the needs and desires of man and his civilization.

Increasing environmental pressures from demographic and commercial development are paralleled in the same community by the increasing desire for greater recreational use. That these can be compatible is clearly shown by the San Diego Bay example. Such community reactions as in San Diego and in San Francisco demonstrate that, while people need commercial development and use, they want a safe and enjoyable environment at the same time.

Social and Economic Trends in the Estuarine Zone

At the present time, the major uses of estuaries, in terms of gross monetary return are: military use, shipping, and industrial activities. These uses are, of course, historical and do not necessarily reflect the uses that would be made of the estuary under today's conditions or future conditions, if each use were to compete for the

water use at the same time. In other words, historical use has brought about the present use imbalance in many estuarine systems. However, given the opportunity to develop, other uses might attain equal importance economically while contributing important social benefits.

Estuaries at the present time represent underdeveloped natural resources that are important to the social as well as the economic well-being of the Nation. Based on present trends and demands, there is little doubt that there will be a tremendous need for estuarine uses other than for military, shipping, and industrial uses. That is, if the facilities are available for recreation, sports, or aesthetic enjoyment, they will be used and used to great advantage from an economic standpoint as well as a social standpoint.

If normal circumstances prevail, the Nation's population and general high standard of living will continue to increase in the coming decades. A moderate estimate projects a doubling of the national population by the turn of the century, with a significant proportion of that growth occurring in urban areas.

The population will be made up of a large proportion of youth and young persons of working ages, with only a moderate increase in the elderly through the end of the century. Personal income will rise dramatically. Estimates of leisure time vary considerably, but all authorities agree that the work week will shorten, from a conservative estimate of 35 hours a week to as little as 20 hours per week. The National Planning

Association has projected that in 1990, ten per cent, and in 2000, twenty per cent of the men between the ages of 25 and 54 will be granted a one-year leave every seven years.

Urban and particularly suburban growth will expand greatly both to accommodate the growing population and to provide amenities that it increasingly demands: single family dwellings, recreational areas, transportation facilities, industrial developments, and so on. These demands will place rapidly increasing burdens on the Nation's resources and its environment. These burdens, in turn, will tax the ability of decision-makers and the Nation's population to cope with the complexity and insistence of the problems generated by a post-industrial, urbanized society.

Information provided by this analysis of national population and economic trends gives only the grossest indication of the activities and expected pressures of population and economic activity on all of the Nation's environment. Analysis of these indicators can only provide a general indication of the magnitude of the demands which will be generated by these forces in the near future on the estuarine zone.

POLLUTION: THE IMPACT OF HUMAN SOCIETY ON THE ESTUARINE ENVIRONMENT

Man has always used the biophysical environment as he needed it for survival and thrown back into it his waste products and anything else he did not need. As long as civilization was limited to small towns and villages the impact of such treatment on the estuarine environment was not noticeable and apparently insignificant. With the development of a civilization based on a complex socioeconomic environment, however, his impact on the natural environment has increased until now the most accurate term to express the relationship of man to his biophysical environment is "pollution."

"Pollution" is the degradation of the biophysical environment by man's activities; it is no longer limited to the discharge of sewage and industrial wastes, but now includes direct or indirect damage to the environment by physical, chemical, or biological modification.

Environmental degradation is the result of often minute changes in water quality, water circulation, or other conditions which are part of the biophysical estuarine environment. There are brightly colored or otherwise visible waste materials which have obvious pollutional implications, but by far the deadliest pollutants are those which are invisible and often unsuspected until the damage is done. These pollutants can be found only by the most delicate

and sensitive tests and, even then, the presence of some highly dangerous materials or conditions can only be inferred by indirect evidence.

Materials and Conditions which Degrade the Environment

One of the major constituents of municipal and many industrial wastes is decomposable organic material. Such materials consist primarily of carbohydrates from plants and paper, proteins from animal matter, and miscellaneous fats and oils. The decomposable organics are not necessarily detrimental by themselves but exert a secondary effect by reducing dissolved oxygen in the water. The level of dissolved oxygen is one direct index of the healthiness of the system. High levels are generally indicative of a healthy system which will support a diverse biota and multiple use. The lower the concentration of dissolved oxygen becomes, the sicker the system is, and the less desirable it is for habitat or use.

Another class of materials, primarily organic, that can have considerable impact on the estuarine ecosystem are the flesh-tainting substances. Generally these materials are contained in industrial waste effluents and they result in offensive tastes, odors and colors of fish and shellfish.

The salts of heavy metals are fairly soluble and stable in solution. Consequently, they will persist for extended lengths of time. Many of these are highly toxic to the aquatic biota, and since many marine organisms exhibit the ability to accumulate and concentrate substances

within their cell structure, the presence of these metals in small concentrations can have deleterious effects.

Aquatic life forms require trace amounts of some minerals and vitamins for growth and reproduction. Elimination of such materials from the environment or their reduction below minimum levels can limit the growth and reproduction of some biota. Conversely, an oversupply of all necessary trace mineral salts and vitamins can stimulate growth, providing satisfactory conditions of temperature, salinity, and dissolved oxygen also exist. An oversupply of inorganic nutrient salts, such as those of nitrogen and phosphorus, may be associated with drastic shifts in the composition of the aquatic community.

One of the many unfavorable effects of municipal and some industrial wastes is the contamination of the receiving environment with bacteria, viruses and other organisms of public health significance. Pathogenic organisms, especially those from the intestines of warm blooded animals frequently persist for sufficient periods of time and distance to pose a threat to the health and well-being of unsuspecting water users. Secondary chances of exposure to these organisms exist through the contamination of shellfish which can be harvested for food.

Among the waste products that are frequently introduced into the estuarine environment are some directly toxic to marine organisms. Toxic materials may exhibit a short catastrophic impact or a more

subtle long-term interference with growth and reproduction processes. The end result is to create a biological desert in which no organism can survive. The pesticide group is of particular concern in the estuarine zone. Estuaries are the terminus for most of the major river systems, and as such they tend to concentrate the waterborne materials carried in by the large terrestrial drainage systems. The biological magnification capability of estuarine animals significantly increases the hazard and destructive potential of any contributed pesticides. The ultimate damage is to stress or eliminate parts of the energy conversion chain in the estuarine environment.

The addition of large quantities of heat from industrial cooling water constitutes a form of pollution which must be considered. The entire ecosystem may be stressed by thermal pollution. The amount of damage is dependent on the resulting temperature of the environment and the species composition of the biotic community. The total range of detriments should be carefully considered on an individual case basis before heat is released to the environment. Heat affects the physical properties of water, the rates at which chemical and biological reactions progress, and can kill living organisms.

Man's activities may affect the rate of sediment inflow, deposition, and outflow by purposely or inadvertently upsetting the natural balance. If upstream erosion is increased due to poor land management practices, the load carried in will increase. Conversely activities along the coast can result in

increased shore erosion, removing more sediment than is contributed. The primary pollutional problem from sediment, however, is from increased influx and accelerated deposition. The detrimental effects of sedimentation are reflected in an impairment of uses such as navigation, recreation, and fish propagation.

One of the greatest threats to the estuarine ecosystem is the ever-present chance for a catastrophic spill of oil or other hazardous materials. The large volumes of petroleum and chemical products transported through the estuarine zone by ships, barges, pipelines, tracks, and railroads present a continuing opportunity for accidental bulk spills. The consequences of these spills depend on the amount and type of material released and the characteristics of the receiving water. They may range in magnitude from tragic loss of life to little more than economic loss for the transporter.

The effect any pollutant has on an estuarine environment depends on where it goes, how strong it is, and how rapidly it is assimilated or flushed out of the environment. All of these conditions depend on water movement and circulation patterns which are in turn governed by the relationship of tide and river flow to estuarine shape and size. Physical modifications such as the dredging of new or deeper navigation channels, building of causeways or jetties, and even construction of pier bridges can cause subtle changes in water movement that can change the balance of environmental conditions in an

estuarine system and result in gradual undesirable changes in the ecosystem in addition to direct habitat damage.

Sources of Pollution

Nearly all of man's activities can result in environmental degradation. Pollutants and polluting conditions are very rarely unique to a particular use or specific activity, but may result from man's existence in the estuarine zone as well as his use of it. The major sources of pollution are these:

(1) Those sources associated with the extent of development of the estuarine zone, including waste discharges from municipalities and industries, and land runoff from these as well as agriculture;

(2) Those sources associated with particular activities of great pollutional significance, specifically dredging and filling, watercraft operation, underwater mining, and heated effluent discharges;

(3) External sources having impact derived through flow regulation and upstream water quality.

Over eight billion gallons of municipal wastes are discharged daily into the waters of the estuarine zone. While most of this volume is domestic sewage, many municipal waste discharges also contain significant amounts of industrial wastes, which may add to the variability and complexity of the wastes discharged. Municipal waste discharges

have four important effects on receiving water quality: depletion of dissolved oxygen, and introduction of pathogenic organisms, settleable material, and inorganic nutrients.

Sewage treatment reduces and alters the impact of municipal waste on the environment. Primary treatment with chlorination will remove part of the decomposable organic material, nearly all of the settleable and suspended solids, and almost eliminate the possibility of pathogens in the effluent. Secondary treatment can almost eliminate decomposable organic material, and some special processes can eliminate certain kinds of dissolved salts. About one half the municipal wastes discharged to estuarine waters receive secondary treatment, with the most extensive use of secondary treatment being in the Chesapeake Bay estuarine region.

Associated with the major metropolitan developments are large numbers of industrial complexes with their attendant waste products. Many of these industrial wastes, especially from the chemical industry, are of such a complicated nature that it is difficult both to identify them and to assess their effects on the receiving streams. Only 4,000 of the more than 200,000 manufacturing plants in the coastal states account for 97 percent of the total liquid wastes discharged. Of the nearly 22 billion gallons of industrial wastes discharged only 29 percent receive any kind of waste treatment.

Intensification of use of the estuarine zone has resulted in many artificial changes being made in the physical structure. Shoreline

areas have been filled to create more land area for residential and commercial use; channels have been dredged and maintained to permit safer and better navigation; and harbor facilities have been dredged and bridges and causeways have been built. All of this activity has had impact on the coastal zone ecosystem, but the activities having the most impact on water quality are dredging and filling. The potential for pollution of the system exists in both filling and dredging; both can introduce foreign materials into the water, destroy aquatic habitat, and alter physical circulation patterns.

The primary source of thermal pollution is from industrial cooling water effluents. Power plants are the major users of cooling water in the estuarine zone, and power generation capacity has approximately doubled each decade during this century. The impact of this growth on the estuarine areas is evidenced by the fact that, in 1950, 22 percent of the power plants were in the coastal zone; it is anticipated that over 30 percent of the plants will be located there in the late 1970's.

Estuarine areas are also very important highways of commerce, and thousands of commercial vessels, foreign and domestic, from ocean liners to barges, traverse the coastal waterways each year. Added to this are many of the 1,500 Federal vessels and many nearly eight million recreational vessels. All of these watercraft carry people and/or cargo, and are a real or potential pollution source.

Mining from the estuary floor causes alteration of the estuarine shape and water circulation characteristics, with a secondary effect being the turbidity problems associated with material removal. Mining of sand and gravel from the estuarine floor are universal while oyster shell dredging in any great quantity is restricted to the Gulf coast. These operations remove part of the estuarine floor with a concomitant destruction of habitat and life. There are also great amounts of suspended and settleable solids frequently released into the water, from which they are redeposited in other places.

The water quality of estuarine areas is dependent not only on direct waste sources but also on the quality of the inflowing streams and runoff entering the system. Tributary influent quality is generally a good index of the type and intensity of land use surrounding and upstream from estuarine systems, and can be a major cause of ecological stress within the system. The complex interactions between fresh and salt water may magnify the effects of pollutants carried into the tidal regime, resulting in quality anomalies completely alien to either fresh or oceanic environments.

Extent of Pollution Effects

Environmental damage from human activities manifests itself in changes in water quality and in changes in the living communities. Either or both may be caused by any of the kinds of pollution or

sources of pollution mentioned earlier. One key to the degree of environmental impact is measurement of alteration in water quality. Extensive data have been collected on a few of the estuaries with the most severe problems, and limited information is available on other estuarine systems to outline the emergence, or document the existence, of water quality problems.

Examples of estuarine systems that show definite documented water quality degradation as a result of human activities are these: Penobscot Bay, Boston Harbor, Moriches Bay, New York Harbor, Raritan Bay, Delaware Estuary, Baltimore Harbor, Potomac River, James River, Charleston Harbor, Savannah River, Biscayne Bay, San Juan Harbor (P.R.), Tampa Bay, Pensacola Bay, Mississippi River, Galveston Bay, Laguna Madre, San Diego Bay, Los Angeles Harbor, San Francisco Bay, Columbia River, Puget Sound, Silver Bay (Alaska), and Hilo Harbor (Hawaii).

Pollutional damage to estuarine ecosystems may be sudden and dramatic as fish or other aquatic life forms suddenly dying, or it may be so gradual as not to be noticed for many years. Many studies of different aspects of estuarine biology have been made, but there are only a few cases in which comprehensive ecological studies have been made of pollutional effects.

All of the 25 estuarine systems listed above also show some ecological damage, but in 38 percent of the estuarine systems of

the United States there is not sufficient information to decide whether there is no ecological damage, or whether there is just no easily identifiable pollution problem present.

The complex nature of pollution in the estuarine zone prevents the separation of sources of pollution, kinds of pollution, and types of environmental damage into neat compartments of cause and effect. All of human activities in the estuarine zone can damage the environment and most of them do.

Wherever people live, work, and play in the estuarine zone the demands of their social and economic activities place stresses on the biophysical environment. These stresses frequently result in degradation of that environment, perhaps not immediately or even in a few years, but nonetheless certain in its devastating final impact.

USE CONFLICTS AND DAMAGES: MAN'S BATTLE WITH HIMSELF AND NATURE

The consequence of damage to the biophysical environment is loss of use either immediately or at some time in the future. Loss of use, however, may also be associated with the appropriation of part of the estuarine resource for one exclusive use even when no damage to the environment itself occurs.

Institutional management must cope with the problems of responsibility and authority in achieving maximum multiple use of the estuarine resource. Within this comprehensive framework technical management must resolve the problems surrounding conflicts of use, competition for the resources of the estuarine zone, and environmental damage. The primary objective of technical management is to achieve the best possible combination of uses to serve the needs of society while protecting, preserving, and enhancing the biophysical environment for the continuing benefit of present and future generations.

The uses of the estuarine zone grew and changed in consonance with population growth and industrial development. Not until recent years was a concerted attempt made to understand and resolve the conflicts that arose in the competition to use and exploit these land and water resources. During the past three hundred years of growth and industrial expansion with its emphasis on economic growth and direct monetary gain, large parts of the estuarine zone were pre-empted or usurped to serve the individual needs of commercial

enterprises. The net result has been less a conflict in existing uses than an exclusion of some uses.

Nearly all estuarine uses involve both land and water, either directly or indirectly. For example, the construction of a manufacturing plant on the shore of an estuarine system may not involve any direct use of the water (even for waste disposal), yet it limits access by its occupation of the shoreline and so may interfere with other uses. Conversely, the disposal of liquid wastes into the water may not use any appreciable space but may make the shoreline unusable for recreation as well as making the water itself unsafe.

The impact of one estuarine use on another may be either "prohibitive" or "restrictive" depending on the kind of use and sometimes on the manner in which it is carried out.

Prohibitive impacts involve permanent changes in the environment and thereby prohibit all uses unable to cope with such changes. The geographical range of such impacts may be from the limited area in which they occur to an entire estuarine system, depending on the nature and size of the change. The impact may be temporary, if it is possible to return the environment to its original form, or it may be permanent.

Any use or activity requiring physical modification of the shoreline, marshes, or bottom of an estuarine system may have a prohibitive impact. Modification of water circulation also tends

to be prohibitive when it has any conflicting impact. Examples of estuarine uses and activities generally having prohibitive impacts are navigation dredging, other dredging and filling, solid waste disposal, construction of bridges, dikes, jetties, and other structures, shoreline development, mining from the estuarine bottom, and flow regulation.

Some estuarine uses may restrict estuarine use for other purposes but do not automatically exclude other uses. These are those activities which do not require a permanent modification of the estuarine system; they generally include those uses directly involved with the estuarine waters and other renewable resources.

Restrictive impacts may involve damage to water quality, living organisms, or aesthetic quality; such impacts may also result from the exclusive appropriation of space. The key feature of uses which cause restrictive impacts is that they may, with proper management, be carried out simultaneously with other uses.

Any kind of municipal or industrial waste discharge may have a restrictive impact and often does. Commercial fishing, recreation, and water supply are the major uses restricted by pollution from liquid waste discharges.

Some kinds of commercial fishing require the use of trawls or the setting of traps or nets that must be left for some time. The use of such devices restricts other uses while the devices are in place,

but there is no permanent appropriation of estuarine waters or space. The major conflict is with recreation in that recreational boating must be excluded from areas where fishing gear is near the surface.

Where there is conflict, the scene is set for trade-off, i.e., a willing substitution of one activity for another. The scene is equally set for uncompensated damage where one user group precludes the activities of a second unrelated user group but does not reimburse them for damage. Actual documented examples of use damages are difficult to find. One major reason is the basic fact that has permeated much of the discussion of economic and social values: Many estuarine values are not quantifiable. While damages to a commercial enterprise, such as commercial fishing, can be quantified in terms of the economic loss, the essentially intangible values of recreation and estuarine habitat are difficult to measure.

Recreational loss would have to be measured in terms of how many people <u>don't</u> swim or go boating in the Potomac River because it is polluted. It is far easier to find out how many people <u>do</u> go there even if it is polluted; even these values are hard to find.

The value of estuarine habitat is just as difficult to establish. There are now about 5.5 million acres of important estuarine marsh and wetland habitat remaining in the estuarine zone of the United States. Perhaps each acre is not valuable by itself, but the total habitat is irreplaceable.

Use damage is not a necessary feature of civilization in the estuarine zone, but use conflicts will continue to exist as more and more demands are made on the natural environment. The ability of any management authority to prevent use damage and to resolve use conflicts depends not only upon its institutional composition and legal authority, but also upon the social, economic, and biophysical characteristics of the estuarine management unit within which its authority is exercised.

The analyses of social and economic values of the estuarine zone examined concurrently with the similar analyses of use conflicts, pollutional effects, and use damages form the basis for resolving use conflicts through the application of technical knowledge, i.e., technical management.

The primary objective of technical management is to accommodate the needed and desired uses of any estuarine management unit within that system without overall damage to the biophysical environment. The ability to achieve this objective depends on the boundaries of the management unit and upon the means available for resolving both prohibitive use conflicts and restrictive use conflicts.

The impact of the social and economic requirements of civilization on the natural estuarine environment is the technical problem with which management must deal, and effective control of this impact can be maintained only if both the major sources of damage and the geographic range of their influence are subject to unified control.

An estuarine management unit, therefore, should consist not only of the estuarine waters, bottoms, and associated marshlands; but it should also include all of the shoreline surrounding the estuarine waters themselves and as much of the adjoining land as is necessary to regulate the discharge of wastes into estuarine waters.

Allocation of part of the estuarine resource for an exclusive single-purpose use is a necessary fact of estuarine management. The shoreline is a necessary location for shipping docks and for swimming beaches, but they cannot both occupy the same place on the shoreline. Similarly, frequently dredged channels and oyster beds cannot occupy the same space at the same time. Resolution of such conflicts can be achieved by allocation of adequate space to each use through whatever institutional mechanism is established.

The evaluation of the effects of prohibitive uses on the estuarine environment is probably the most difficult problem currently facing technical management. The immediate and obvious effects of the habitat loss associated with such uses can be measured and described fairly easily, but the ultimate results of the modification of water movement patterns and flushing characteristics can only be estimated in general terms.

In nearly every problem associated with prohibitive use conflicts, however, the area of primary concern is the effect on the estuarine ecosystem of any physical modifications proposed; the limitations of

knowledge mentioned above, therefore, present a critical problem in present efforts to resolve prohibitive use conflicts.

A more difficult problem arises where there is involved a massive dredge or fill operation with its concomitant immediate effect on the ecosystem. When such modifications are a necessary or desirable development of the environment it may be necessary to forego the habitat use; however, in many cases it may be possible to create new, equivalent habitat in a different part of the management unit, or it might be possible to restore part of the damaged environment.

While the resolution of prohibitive use conflicts requires the abandoning of one use in favor of another, the potential for carrying out any modifications necessary so as to increase habitat value as well as economic value should be a key factor in the resolution of such problems.

Disposal of liquid wastes to the estuarine environment is the major restrictive use impact of the socioeconomic environment. This use conflict can be resolved completely either by treating all wastes to such an extent that they do not interfere with any other uses or else removing them entirely from the environment.

Technology exists to provide thorough treatment for nearly every kind of municipal and industrial waste, and there is no reason not to provide treatment sufficient to protect the environment from damage and to permit other uses. Treatment requirements for

different wastes may vary from place to place according to local conditions, but damage to the environment and restriction of other uses can be prevented.

Water quality standards have been set and are now being implemented in all the coastal states. These standards are the foundation upon which the effective control of estuarine pollution rests, and they provide the framework within which technical management can effectively operate.

Estuarine waters even in busy harbors are used for recreational purposes by those who cannot afford to go elsewhere, regardless of whether the waters are safe for body contact or not. Also the role of the estuarine zone as a nursery for some fish, passage for others, and a residence for still more is readily apparent although its full implications in the energy conversion chain are not understood. For these reasons the long-range achievable water quality goal of estuarine management should be to keep all waters safe for direct contact by humans and also usable as a fish and wildlife habitat.

MANAGEMENT AND KNOWLEDGE

A great deal of technical and socioeconomic knowledge is necessary to support a comprehensive program of estuarine management. This knowledge must be supplied through multidisciplinary efforts. The knowledge thus developed must include: (1) knowledge and understanding of the biological, physical, and chemical factors of the estuarine zone, (2) knowledge of the institutional framework governing each portion of the estuarine zone, (3) knowledge of the demographic, social, and economic factors and their trends, (4) establishment of goals and uses so that future studies can be relevantly oriented, and (5) an augmentation and synthesis of all this knowledge.

The available pertinent information on these subjects has been gathered, organized, and coordinated into the National Estuarine Inventory. This compilation revealed many areas in which information is poor or is lacking; some can be obtained by careful, routine monitoring of the estuarine environment. The acquisition of other knowledge requires an integrated, multidisciplinary research and study program.

The most important knowledge to be gained is an understanding of the estuarine environment adequate to permit the recognition and interpretation of interrelationships which, in turn, provides the capability to predict the effects of natural and human activities

in the estuarine zone. The research and study programs which will yield this information are in the categories of:

(1) Ecology, taken to include base line information, broad ecological studies, biology, water quality, natural variability, and interface factors.

(2) Toxicity, taken to include bioassay needs and methodology, sublethal effects, and mortality phenomena.

(3) Microbiology, taken to include the regeneration of plant nutrients, biodegradation of organic wastes, eutrophication, and pathogens.

(4) Physics and mathematics, taken to include hydraulics, sedimentation, effects of structures and physical modifications, and physical and mathematical modeling.

(5) Planning, taken to include economics, law, social and demographic factors and trends, resource evaluation and allocation, and the role of technical research and study in supporting a comprehensive management program.

(6) Needs of researchers, taken to include environmental modeling, methodology (both laboratory and field techniques), data processing, training needs, and estuarine zone laboratories.

The various agencies and institutions working in estuaries should coordinate

their activities; results of research should be widely disseminated. The national program for estuarine study should be developed with strong regional emphasis based on ecology, geography, and a commonality of problems and objectives. Planning for estuarine use and development must be based on broad public benefits rather than narrow private interests. A system of criteria by which to gauge estuarine quality is necessary. Key management roles require adequately trained people in ecology, engineering, economics, planning, and law. Finally, the public must be informed of its stake in the estuary.

The Federal and State roles in estuarine monitoring, research, and study should be a joint one with their respective actions complementary. The State role is basically to manage its estuarine and coastal zone resources, coordinate the research activities of its appropriate agencies and institutions, and to augment and encourage the development of new knowledge applicable to its estuaries and coastal area. The Federal role, a residual one, is primarily to assist the States through such means as: grants to States and to academic institutions, organizations, and individuals to support needed investigations; perform broad studies not of a local nature; participate in State and local studies; coordinate Federal estuarine and coastal zone research and study activities; and organize and coordinate its laboratory resources so as to cooperate with and assist States, localities, and academic institutions supporting and using research in the estuarine and coastal zones.

CONCLUSIONS

The ever-increasing and often conflicting social and economic demands of modern human civilization are placing significant pressures on the limited estuarine resources of the United States. The delicately balanced natural ecology of the estuarine zone has been subjected to over three hundred years of exploitation and alteration: objective analysis of the results of this use and misuse shows that positive action is needed now to preserve, conserve, and enhance the finite resources of the coastal zone.

Natural estuarine ecosystems are communities of living organisms existing in reasonably delicate balances determined by definable but poorly understood external environmental conditions. These systems exist only in the geographically and physically limited narrow interface where the land meets the sea; where over one-third of this Nation's present population and industry is concentrated into 15 percent of the land area.

This society uses the resources of the estuarine zone and coastal zone to serve not only those social and economic purposes for which the zone is uniquely valuable such as recreation, fishing, and navigation, but also to satisfy other requirements of civilization wherever organized human society exists. These uses include industrial, residential, and commercial land development, exploitation of mineral resources and fossil fuels, water supply, and a place to dispose of the wastes from

all of these activities. The economic pressures of these diverse and often conflicting uses have often resulted in a preemption of the estuarine resource for individually profitable uses to the limitation or exclusion of other valuable, but much less quantifiable, uses.

The natural aesthetic and habitat qualities of the estuarine and coastal environment enhance its value for many economic uses and also make it a recreational resource of great commercial, as well as social, value. It is the value of the estuarine zone as a fish and wildlife habitat, a recreational resource, and an aesthetic attraction that make the estuarine zone a unique feature of the human environment, yet it is these very values that have been generally ignored in satisfying the immediate social and economic needs of civilization. The overall value of the estuarine zone for commerce, navigation, and transportation has been detailed in this report to the extent that definitive economic data are available. The values of the estuarine zone as a fish and wildlife habitat, as a recreational facility, and as an aesthetic experience are probably greater than they are for commercial exploitation but, unfortunately, we have not yet developed the ability to adequately express these social and humanistic values in quantitative terms.

The pressures of population growth and economic development associated with increasing urbanization and industrialization in the estuarine zone

have permitted and, indeed, encouraged dredging and filling operations, resulting in the destruction of many valuable areas of estuarine marsh and wetlands. The complete and irreversible loss of this habitat eradicates not only the resident and transient wildfowl dependent upon it, but also the life support system of the bulk of the Nation's sport and commercial fish. True, we cannot now establish a direct quantifiable relationship describing the acreages of wetland, marsh, or estuary necessary to support our coastal fisheries, but we do know that this relationship does exist and that the necessary habitat must be protected. Activities generated by these same social and economic pressures habe degraded estuarine waters, severely damaging not only the estuarine ecosystem, but also the other essential human uses of the estuarine resource.

The value of the estuarine resource to the Nation lies more in the multiple purposes it can serve than in the economic worth of a single use, and it is this overriding national value which has been minimized or ignored. Population and economic development pressures are increasing more rapidly now than they have in the past, and continuation of present attitudes and approaches toward use of the estuarine and coastal zone can bring only an increasing rate of damage to its ecology and to the resources it supplies.

Properly supported and managed research and studies to increase present knowledge and information can contribute greatly to effective technical

management of the estuaries and coastal areas.

Over and above this, though, must be added a stronger and better institutional environment to provide the umbrella for the integrated and comprehensive planning needed to convert the processes of loss and damage to actions leading to enhanced and broadened values. The program for accomplishing this is presented in Part III that follows.

* * *

Part III

RECOMMENDATIONS — THE PROPOSED PROGRAM

INTRODUCTION

At present, planning and development in the estuarine zone is done on an independent piecemeal basis. The resultant losses to fish and wildlife resources, the habitat upon which they depend, and the impact on recreational, scenic, esthetic qualities, and water quality itself appear to be proceeding at an increasingly rapid rate. Whole sectors of the public object, but economic and political pressures, particularly at the local level seem to win out and the irreparable damages to estuarine and coastal regions continue.

It is thus evident that a higher order of planning and evaluation is needed. The planning must be both integrated and comprehensive and in the concurrent evaluation, involve all the uses of the waters and the adjacent lands. The impact on the total environment must be considered and be paramount to single purpose aspects.

It is the purpose of this part of the study to recommend the program that will provide for the necessary planning and its implementation at the various levels of government. This was directed in the words of Congress as follows:

> "Recommendations for a comprehensive national program for the preservation, study, use, and development of estuaries of the Nation, and the respective responsibilities which should be assumed by Federal, State, and local governments and by public and private interests."

As the study proceeded it was determined quite early that the direct relationship of the coastal areas to the estuaries made it impractical to attempt to consider them separately. This was true because of their close proximity, their continuous influence upon each other and because both are affected by the same economic and social pressures, thus the recommendations that follow apply equally to the estuarine areas proper and to the entire coastal zone, that overall area where the continent and the islands meet the sea.

A comprehensive program for the management of the estuarine and coastal zonesof the Nation, must have as its primary concern the institutional environment, i.e., the framework which includes the forms of law, political institutions, and organizational mechanisms, that man must use to provide himself the capability to control, develop, and use these zones. Once this framework is established it becomes more easily possible to conduct activities designed to improve the biophysical environment and the socioeconomic environment.

What is proposed is a program that recognizes the primary responsibilities of the States in a management program for their estuarine and coastal areas, and on the Federal side provides for the coordination of Federal activities in these areas and for assistance to the States in their management activities.

Any comprehensive national program for the estuarine and coastal zone must provide flexibility in many ways to fit regional and local conditions and situations, but regardless of variables it must establish a guiding policy and a set of objectives. Regardless of variables, in order to be effective the program must provide for: (1) planning and implementation; (2) active administration in terms of regulation,

control, coordination and financing; and (3) the development of the knowledge and data necessary as a basis for all action.

This report does not recommend any particular type of organization at the State level but only what it must accomplish. The particular organization, it is felt, will vary to fit the situation. Also, there is awareness that some States have established estuarine and coastal management programs and that others have them in the planning stage. These programs, where known, have been studied, and their ideas included herein.

THE ELEMENTS OF A COMPREHENSIVE NATIONAL PROGRAM

It follows, therefore, that any program of management must contain at least the following elements:

(1) Mutually agreed-upon policy, objectives and functions.

(2) Legislative authorization to carry out the program's functional activities.

(3) Development of the basic knowledge necessary for effective management.

(4) Provisions for planning and implementation.

(5) Active administration in terms of regulation, control, and coordination.

(6) Financial and manpower resources.

(7) Public awareness and acceptance.

The mutually agreed-upon policy and objectives are the basis and the reason for this study, and is described below, as a <u>national policy</u> not a <u>Federal policy</u>.

The remaining elements are contained in the roles and recommended responsibilities to be assumed at the various levels of government. For most activities required, there is a continuous series of concurrent Federal, State, and local jurisdictions. This is present now under current law, and it must be assumed that the situation will continue to exist, as many functions must be carried out at each level of government. There is also that essential element of public awareness, the non-governmental public and private interests, whose support of a national program through political and social processes can bring much progress towards better management.

It must be kept in mind that the importance of the estuarine and coastal areas is not limited to the coastal States and communities. The economic, social, and environmental use and well-being of the estuarine and coastal zones of the Nation are of vital interest to the inland States as well. It is for these reasons that there must be a national program that gives adequate consideration to this breadth of interest and which embraces well-defined roles for the Federal, State, and local levels of government as well as for public and private interests.

Any recommended national policy must reflect the fact that there is strong national interest in the effective management and protection of the estuarine and coastal zone for the following reasons:

(1) The pressures of population growth and economic development, including requirements for industrial, commercial, residential development, recreation, exploitation of mineral resources, and fossil fuels, transportation and other navigation, waste disposal, and exploitation of fish and other living marine resources, impose an increasing number of conflicting demands upon the finite resources of the coastal zone.

(2) Estuaries, marshlands, and other parts of the coastal zone contain extremely valuable habitat for fish and wildlife which move beyond State boundaries; such areas are vital to the life support of a major part of the Nation's commercial and sport fisheries harvest; such areas, particularly the estuaries, constitute ecological systems which are susceptible to destruction and disruption by man.

(3) Continued unplanned or uncoordinated development activities in the coastal zone pose an immediate threat of irreversible harm to the coastal zone and its resources and a loss of the benefits it offers.

(4) The coastal zone is a valuable area for multiple economic, recreational, and resource uses.

(5) The interest in the coastal zone extends to the citizens of all the States, and is not limited to the citizens in the coastal States.

Policy and Objectives of a Comprehensive National Estuarine and Coastal Zone Management Program

The Recommended National Policy.

Achievement of the best use of the values of the estuarine and coastal zones through a balance between: (a) multi-purpose development; (b) conservation; and (c) preservation over both the short and long-range. Priority consideration should be given to those resources that are non-renewable and to maintaining those resources and uses which are estuarine-dependent. It shall also recognize that the primary responsibility for management of the estuarine and coastal zones rests with the States.

This recommended national policy recognizes the vital need in present and future programs to:

- --Encourage urban and industrial growth and the resulting land use in a manner to preserve the maximum of the estuarine and coastal zone resources and to insure the greatest number of beneficial uses.
- --Recognize that estuarine-dependent land uses require preference and that some uses such as residential and some industrial uses do not need shoreline locations.
- --Conserve the estuarine and coastal environment to sustain and enhance its nursery value, its wildlife habitat value, and its commercial fisheries value.

--Develop and make accessible the many forms of outdoor recreation and the aesthetic values offered by the estuaries and coastal areas.

--Reduce to an acceptable minimum the adverse effect of man's use of the estuaries and coastal areas and accept preservation as one means of reasonably guarantying the opportunity to exercise future options.

The recommended National Policy will put in effect a comprehensive national program for the effective management, beneficial use, protection and development of the estuarine and coastal zone of the Nation involving Federal, State, and local governments, and public and private interests in an appropriate manner. It will permit the optimum use of this vital resource by recognizing the existence of competing uses and accommodating them through appropriate management and, further, conserve these resources in such a manner as to keep open the options for various uses in the future and not foreclose them. This management system will recognize the primary and constitutional role of the States in managing their resources as well as the role of the Federal Government in protecting the wider national interest. The principal goal of the national program is the use of the estuarine and coastal zone for as many beneficial purposes as possible and, where some uses are precluded, to achieve that mix of uses which society, based on both short and long-range considerations, deems most beneficial.

THE OBJECTIVES OF A NATIONAL PROGRAM OF MANAGEMENT

Without attempting to assign responsibilities of functions to the various levels of government at this point, the objectives of a comprehensive management plan are listed below. These objectives also constitute a reasonably thorough set of guidelines for an acceptable management plan.

(1) Equitable consideration in management decisions of the views of all public and private interests concerned with the use and preservation of estuarine and coastal resources.

(2) Adequate planning, i.e., the preparation and adoption by the appropriate government, of plans governing the balanced development, conservation, and preservation of coastal and estuarine resources. Elements of such a plan may vary but ordinarily should include determinations of immediate and long-range needs and objectives, water quality standards, zoning of land use, and any public or private facilities, sites, etc. What is needed is the construction of an optimum resource utilization profile for each estuary and coastal area based on an objective means of value identification and appraisal. Specific uses for various parts of an estuary or coastal area must be determined and comparative values placed on these uses in terms of the accepted national policy. Specific uses are:

--Industrial and commercial location and use

--Recreation and scenic enjoyment

--Preservation of fish and wildlife and their habitat

--Residential - both urban and suburban development

--The exploitation of mineral resources including oil, gas, sulfur, sand and gravel, and others

--Generation of electrical power

--Water supply

--Exploitation of living resources including fish, shellfish, other wildlife, and the pursuit of aquaculture

--Transportation

--National defense

--Waste disposal

--Scientific research

In placing a value on the above uses, consideration must be given to the following criteria:

(a) Multi-purpose use;

(b) Preservation of the estuarine habitat essential to living resources;

(c) Use for estuarine dependent activities; and

(d) Conservation of non-renewable resources.

(3) Implementation, i.e., the making and execution by government of decisions as to which alternative plan will

achieve for all concerned the best use of the resource. The three broad forms of governmental regulation include:

(a) The establishment and enforcement of policies controlling use and/or modification of estuarine and coastal resources by public authorities through:

[1] Water quality and other standards, zoning of land use, and official use and management plans.

[2] Permits, licenses, etc., governing permissible uses and/or modification of estuarine and coastal resources.

(b) Promotion of established plans and policies through various forms of incentives and assistance.

(c) Control of use by selected acquisition, development and/or administration by government itself.

(4) Service activities to assist planning, regulation, and the use of estuarine and coastal resources including:

(a) Funding, through grants, credit, subsidies, or other financial inducements;

(b) Technical assistance;

(c) Research, studies, and inventories; and

(d) Information and educational programs to improve public awareness and manpower development programs to provide trained personnel.

(5) Participation in management by all levels of government, with the primary management responsibility of the States preserved and enhanced, and with existing management authority and programs retained where these contribute to achieving the other objectives.

RESPONSIBILITIES AND RECOMMENDED ROLE OF THE STATES IN THE COMPREHENSIVE NATIONAL ESTUARINE AND COASTAL MANAGEMENT PROGRAM

The States, in our Federal system of government, occupy a strategic position in the management of the Nation's estuarine and coastal resources. As holders of residual sovereignty, they possess ample authority to manage these resources as they see fit, subject only to limitations imposed upon them by the Constitution, by the Congress acting pursuant to constitutionally authorized powers, and by their own constitutions. Moreover, even in those areas in which the Federal Government exercises exclusive or primary authority, the nature of our political process gives State officials substantial power to influence the objectives and exercise of Federal policies.

The strategic State position is also a direct result of the on-scene nature of the State function — the interface between the forces of politics, business, and people and their respective ambitions for putting to use the storehouse of available estuarine and coastal resources. It is in the State Capitols that many of the major decisions will be made that will determine the success of a national estuarine and coastal management program.

The State Responsibilities

Seven aspects of the States' possession of this residual sovereignty which relate more specifically to the management of estuarine and coastal resources, help underscore the States' strategic and primary

responsibility. First, although the Federal role has expanded in recent years, the States retain primary authority and responsibility for the prevention and control of water pollution. Second, they hold title to wholly or partially submerged lands and mineral resources in the estuarine and coastal zone and are responsible for administering these, through retention by the State or through their disposal or lease, in the public interest. Third, the States possess primary authority to decide, either directly or through their local subdivisions, how the shoreline and related uplands in the estuarine and coastal zones are to be used for various purposes, i.e., trade and commerce, industry, parks, recreation, etc. Fourth, the authority of local governments generally in managing the water and land resources in estuaries is determined by the States. Fifth, the exploitation of the fisheries and other living estuarine and coastal resources is under State control to the seaward boundary of U. S. territorial seas. Sixth, the nature and forms of interstate cooperation in managing the Nation's estuaries is a matter which the States largely decide. And, finally, each State presides over the common law which governs private relations in the development and use of estuarine and coastal resources, and resolves the conflicting rights, interests, and privileges of its citizens in using these resources.

The Recommended State Role

Clearly, therefore, it is upon the States that the Nation must place its major reliance in achieving that reasonable compromise between

private rights and expectations, on the one hand, and the collective or public interest, on the other. It is also upon the States that the Nation must rely primarily for the integration of Federal service functions into State programs and, even more important, for the development of suggested reconciliations where the regulatory or service programs of different Federal agencies in a specific estuary are in conflict. These are the heart of this study's recommendations for sound management of the estuarine and coastal resources.

Responsibilities inherent in this strategic and primary role of the States in improving management of the Nation's coastal resources are both immediate and of a more long-range nature. The immediate role to be played by the States includes:

(1) Vigorous implementation of water quality standards established for each State's estuarine and coastal waters.

(2) Maximum use of the States' available existing authority to halt or minimize further undesirable physical modification of estuaries through dredging, filling, and drainage.

(3) Immediately establishing and maintaining, if presently lacking, effective interstate, interagency, and State-local coordination of estuarine and coastal management programs.

(4) Conducting an early evaluation of the impact on the estuaries as a result of upstream water and related land resource development and the occurrence and growth of upstream waste discharges, taking into account the interstate nature of particular interstate streams.

(5) Making an immediate review of the jurisdictional relationship between the States and the subordinate units of government in matters dealing with the establishment and enforcement of land-use plans, and the importance of the relationship between land use and the quality of the estuarine and coastal environments.

(6) Undertaking a thorough review of the present estuarine and coastal management capabilities of the State and its subordinate governmental units for the purpose of identifying steps needed to strengthen the State's long-range management effectiveness.

(7) Formulating and putting into operation a comprehensive statewide program for the management of its estuarine and coastal resources.

RECOMMENDATIONS FOR NEW STATE PROGRAMS AND ORGANIZATION

Effective discharge by the States of the all-important role which they occupy in achieving comprehensive and sound management of estuarine and coastal resources will in many instances require legislation establishing new management authority and organization.

The exact form such new authority and organization should take may well vary from State to State. Each State's action in this regard will, as it should, reflect its own special political and governmental traditions, the present organization of the State government, and the current division of authority and responsibility between the State and its local governmental units. Moreover, the estuaries themselves vary in their nature and the uses for which each is most suited, the degree to which the estuarine and coastal zone has been developed for various purposes, and the dimensions and complexity of their management problems. These differences, too, suggest that, as they seek more effectively to manage estuarine and coastal resources, the response from the States need not, and should not, be rigidly uniform.

Indeed the innovations and experiments which the States' responses can be expected to produce are regarded as a positive good and are therefore encouraged. The recommendations which follow should be viewed in that light and also as reflecting and drawing upon the significant improvements which some States already have instituted in their estuarine and coastal management programs.

It is recommended that each State, if it has not already done so, take action along the following lines to improve its estuarine and coastal management capability and effectiveness:

(1) There is a primary need to provide organizational arrangements in the State governmental structure with the authority and resources to administer State-level estuarine and coastal management functions, or, alternatively, to coordinate State-level management activities in the estuaries, including State-local, interstate, and State-Federal relations. Such organizational arrangements should be facilitated by the proposed new program of Federal grants (outlined under Federal Role) for the administration of the State estuarine and coastal management programs. The State should coordinate its own programs with the appropriate part of Federal programs.

(2) Improve the States' long-range management capability through such other measures as:

(a) Preparation of an official use and management plan for each of the State's estuaries and coastal zones, either by the State or by general or special purpose subdivisions with State participation and assistance and through the use of public hearings

at critical stages in the development process. This plan should be appropriately coordinated with Federal agencies, State agencies, local governments and other interests; and with plans for managing the land and water resources in the estuary's tributary streams, metropolitan area plans, economic development plans, etc.

(b) Instituting State-level permit requirements for dredging, filling, or other modification of wetlands and other estuarine and coastal resources in areas not subject to exclusive Federal regulation.

(c) Requiring all State and local agencies engaged in activities which may physically or otherwise modify estuarine or coastal resources, either directly or through issuance of permits, licenses, leases, etc., to comply with the approved use and management plan for the estuary in question. In the absence of such plan, the agency should be required to:

[1] Give notice of the intended action and hold a public hearing before acting, if another governmental agency gives notice that a substantial adverse effect on estuarine or coastal resources or their use is a

likely result.

[2] Minimize adverse effects on estuarine and coastal resources and their use. Provisions for such requirements also should authorize denial of such permits, licenses, etc., based on the possibility of such adverse effects.

(d) Where necessary, initiate legislative and judicial proceedings to resolve problems in establishing the States' title to tidal lands, wetlands, etc., and in regulating use of estuarine and coastal lands under private ownership.

(e) Strengthening selective land acquisition and development programs for recreation and conservation purposes.

(f) Instituting State-level authority to review land use, zoning, and other action by local governments and to veto if inconsistent with the State-adopted management plan for that estuary.

(g) Augmented funding of all components of the States' comprehensive management programs.

(h) Developing interstate agreements for the conduct of joint or coordinated planning or other management functions in interstate estuaries.

(i) Establishing appropriate intrastate regional management organizations or special districts to provide effective local implementation of the use and management plans for intrastate estuarine and coastal zones.

(j) Authorizing local governments to exercise tax policies designed to facilitate the preservation of estuarine and coastal sites which should be preserved and used in their natural state.

RESPONSIBILITIES AND RECOMMENDED ROLE OF LOCAL GOVERNMENT IN THE COMPREHENSIVE ESTUARINE AND COASTAL MANAGEMENT PROGRAM

The local governments of this country are subdivisions of the States and are created by the States for a wide varietv of purposes. These purposes may range from specific functions such as water supply, sewage collection and treatment, port development and operation, etc., to general purpose units of government such as counties, cities, and towns.

Responsibilities of Local Government

It is with the general purpose units of government that the responsibility rests for many of the day-to-day decisions that have impact on the quality of the estuarine and coastal environment. The responsibility to control the character and location of shoreline developments through land use planning and zoning and the enforcement of zoning requirements resides with the local governments. The responsibility to control waste discharges and land drainage exists largely with local governments. The interface between people and government takes place largely at the local level. Because of these responsibilities and relationships it is important that we be aware of the extent to which the local governments have been effective in influencing the balance between the destruction or misuse of the estuarine and coastal resources, and the development of plans for their effective comprehensive management. For the most part local governments have not made a significant contribution toward bringing about balanced use of the estuaries and

their related land resources.

While the States have retained control of the uses of estuarine waters, local governments have been delegated the prime responsibility for managing the adjacent land areas, which in many cases has included much of the marsh and wetland resources. The local governments, inadequately staffed and frequently too small to encompass an entire estuarine or coastal area, lacking funds and receiving little guidance, coordination, and supervision from the States, often have been subjected to severe economic and political pressures to proceed with unplanned or limited purpose development without an adequate appraisal of the long-range adverse impacts on the estuarine and coastal environment. As a result all too many valuable estuarine and coastal resources continue to be destroyed or greatly diminished in their usefulness.

The Recommended Role of Local Government

Despite this rather unhappy picture, the role of local government in the management of the estuarine and coastal zones is a crucial one because it is "on scene" and directly concerned with the people, industry, the land and water.

This singularly important role in estuarine and coastal management includes such things as waste collection, treatment and disposal, land use planning and control, and the development of estuarine and coastal areas for commerce, transportation, recreation, etc. It also includes

the development of support for regional programs for estuarine and coastal management and the crucial function of explaining to its citizenry the importance and impact of local governmental activities upon estuarine and coastal resources and their use.

With increased attention to coordinated planning of the estuarine zone and its related land resources and with increased assistance and improved supervision from the State level much more can be accomplished at the local level of government. As this takes place there should be an expanded and increasingly effective role for the local government to play.

This expanded role should provide for:

(1) Improvement in the collection, treatment, and disposal of wastes.

(2) Development of local laws and ordinances for estuarine and coastal zone preservation and management, including control over shoreline construction activities.

(3) Effective enforcement of local laws and regulations.

(4) Comprehensive surveys of ownership, land claims, and leases through title checks and an updated land register to clarify land ownership.

(5) Sounder land and water use planning and zoning

practices, including the development of more flexible and imaginative approaches, such as planned unit development, cluster zoning and subdivision control.

(6) Use of tax assessment and land valuation policies to induce sound conservation and development practices through such means as preferential assessment and deferred taxation.

(7) Providing public ownership or access to selected estuarine and coastal areas for whatever purposes that are necessary for sound management of estuarine and coastal zones and related land resources.

(8) Active participation in State and Federal estuarine and coastal management programs.

(9) Active participation in appropriate regional management organizations, which would cover the entire estuarine and coastal zone problem area. These organizations may be multifunctional, and in urban areas, metropolitan in character dealing with such problems as water pollution control, port development, transportation, hurricane, flood and erosion control, architectural preservation, recreation, etc. The regional management organization may have limited purpose or broad management responsibility, including regulatory power over dredging and filling, zoning, land-water use, eminent domain and revenue-raising

power, etc.

(10) Development of public education, information programs, including cooperative efforts with private groups in order to encourage local initiative and support for balanced use of estuarine and coastal zones.

(11) Development of local professional and technical training programs for employees of government agencies and private industry to foster understanding of and capability to resolve problems and carry out functions related to the estuarine and coastal management program.

THE RESPONSIBILITIES OF PUBLIC AND PRIVATE INTERESTS

If the Nation is to achieve a sound balance between the development of its estuarine and coastal resources for all beneficial purposes and their conservation and preservation for future use, it is essential that public and private interests in the nongovernmental sector of our society meet their responsibilities for achieving that goal. It is also essential that the public and private interests have an opportunity to exercise their responsibilities against the back-drop of an announced national policy and in terms of announced plans for estuarine and coastal zone management toward which they have made a constructive contribution.

Many of this Nation's estuarine and coastal resources continue to be endangered because of a failure to achieve in governmental programs a proper balance between the development of these resources for all beneficial purposes and their preservation and conservation. The responsibility for this dire condition ultimately rests with the public and private forces within American society that thus far have controlled the use and management of these resources.

This means too that the reversal of short-sighted policies now in force will not occur until there emerge within our society new conceptions of what constitute the real public and private interest in the use of these resources. Only as these expressions of desirable new goals and values evolve, and receive strong and effective articulation by public and

private interests within the nongovernmental sector, will our management of estuarine and coastal resources, both in the private sector and by governments responding to social and political pressure, be redirected toward sounder use and management objectives.

Responsibilities of Public Interests

From public interests--citizen groups, conservation organizations, professional societies, the Nation's educational institutions, and others--there is need for continuing action in three broad areas. The first is educational activity which is the prerequisite to the successful reversal of present short-sighted estuarine and coastal management policies; and, further, through active and vigorous paricipation in the political and governmental processes, to work for the implementation of sound estuarine and coastal zone programs at all levels of government and in the private sector.

A second broad area of responsibility is the support of research programs of governmental bodies through nongovernmental studies leading to improved understanding of the nature and behavior of estuarine and coastal resources, their interrelationships, etc. Continuing studies directed toward appraising and improving Federal, State, and local management of the estuaries and coastal areas also are a critical need and a special responsibility of groups outside government.

The third broad area of responsibility is to support the objectives of the national policy through public, but nongovernmental, acquisition of estuarine and coastal sites which should be preserved in their natural state and to demonstrate new ways of achieving balanced development, conservation, and preservation of estuarine and coastal resources.

Responsibilities of Private Interests

From private interests--ranging from the largest national industrial corporations to the local individual develooing real estate in the estuarine and coastal zone--there is an equallv important need for action in four broad areas. These are, first, to recognize that the public interest often is identical with the true private interest, particularlv if the latter is viewed in the perspective that includes all other private interests and the long run; and further, to recognize that where such is not the case, the private interest must be subordinated to the larger public interest.

A second responsibility, and one private interests share with governmental and other public entities, is to consider in advance the effects of proposed actions in the estuarine and coastal zone on other uses of estuarine and coastal resources and to minimize, wherever possible, the advserse effects upon these other uses.

Third, as special beneficiaries of the development and use of estuarine

and coastal resources for their own private purposes, private interests have the responsibility of joining in research and educational programs aimed at broadening and improving the general public's understanding of the importance and nature of estuarine and coastal resources. To make this possible there is need for support for research institutions affiliated with academic institutions to provide to governments at the Federal, State, and local level the knowledge necessary for management. There should be governmental and private participation in such institutions and part of the States' goals should be the training of both professional and technical personnel in the problems of the estuarine and coastal zone.

Finally, it is the responsibility of the private sector to participate in political and governmental processes so as to insure the proper recognition, both in the national program and in use and management plans for specific estuarine and coastal areas, of legitimate private interests.

RESPONSIBILITIES AND RECOMMENDED ROLE OF THE FEDERAL GOVERNMENT IN THE COMPREHENSIVE NATIONAL ESTUARINE AND COASTAL ZONE MANAGEMENT PROGRAM

The responsibility for leadership in defining the policy and objectives of a national program for the comprehensive management of the estuarine and coastal zones of the United States rests with the Federal Government. It is also the responsibility of the Federal Government to implement its portion of the announced national program; to coordinate the activities of its respective departments and agencies; to define the Federal role to be established and maintained with State, interstate, and local governments as well as with a wide variety of public and private interests; to identify Federal jurisdictions in the estuarine and coastal zones, and to relate these jurisdictions to those of State, interstate, and local governments to exercise its jurisdictional responsibilities to prevent the destruction and misuse of the resources of the estuarine and coastal zones; to evaluate the impact of Federal and federally supported water and related land resource projects upon the downstream estuaries and coastal areas, especially for interstate and international river basins; to perform the functions that are exclusively Federal in nature in such a manner as to establish a leadership example for other governmental, public, and private interests.

National Interests

These responsibilities coupled with the role that follows make up a rather thorough and detailed picture of the national interest in the estuarine and coastal zones.

The Recommended Federal Role

The role described herein includes what is now being carried out by Federal agencies and that which must be done, in addition, to discharge Federal responsibility in achieving comprehensive and effective management of the Nation's estuaries and coastal areas. It is important to stress that the Federal Role is not the primary one in this regard, let alone the exclusive one. It is rather one of sharing authority over resources over which the States exercise primary jurisdiction. Nor is the Federal Role, in general, new, much of it having developed through the years.

What is increasingly evident, however, is that the national program directed towards achieving the best use of estuarine and coastal resources requires also a strengthening of the role of the Federal Government in that program.

Viewed against that backdrop, the Federal Role should be to:

(1) Provide the impetus for the initial establishment, and progressive improvement, of the national program by the enactment of Federal legislation enunciating a national policy and providing grants to States for the development and implementation of comprehensive estuarine and coastal zone management plans.

(2) Provide continuing support and guidance to the States through:

(a) Grants to State, interstate, and local programs for the purposes of:

[1] Development of use and management plans for specific estuaries and coastal areas.

[2] Selective acquisition and development of estuarine and coastal sites for recreation and preservation purposes.

[3] Research, study, and training in estuarine and coastal problems.

[4] Inventory activities in the States' estuarine and coastal zones.

[5] Administration of State (including special intrastate districts created by the State) and interstate management programs to implement State-approved management plans.

[6] Waste collection and treatment facilities.

[7] Support of estuarine and coastal zone laboratories.

(b) Cooperative activities to prepare estuarine and coastal management plans initiated either by the States or by a Federal agency pursuant to established authority.

(c) Technical advice and assistance.

(d) Provision of services such as navigation channels; flood control and protective works, beach restoration, aids to navigation, and environmental prediction, including weather, tides, etc.

(e) Promotion of, and guidance and support to, cooperation among the States in managing interstate estuaries.

(f) Recommendations and advice to the States and interstate agencies concerning their estuarine and coastal zones management policies.

(g) Provision of information and education to the public concerning estuarine and coastal resources, programs, and problems.

(3) Complete and maintain the broad national inventory of the estuaries and coastal areas and their resources initiated by the National Estuarine Pollution Study and the Inventory directed by the National Estuarine Protection Act (P.L. 90-454).

(4) Continue broad estuarine and coastal studies not of a local nature. Examples are the National Estuarine Pollution Study by the Department of the Interior; the same agency's study under the National Estuarine Protection Act of the feasibility and desirability of establishing a nationwide system of estuarine preserves; the comprehensive study by the Corps of Engineers of Chesapeake Bay,

authorized in 1965; and the survey, authorized in 1968, by the Corps of national shoreline erosion problems.

Additional broad scientific studies in hydrology, living resources, and ecology are needed; and, in particular, a study of the means of establishing values associated with the various uses of the estuarine and coastal zones.

(5) Participate in local and regional studies where appropriate to assist local and regional management.

(6) Assure appropriate Federal performance under regional and international obligations for the management of flyways, fisheries resources, etc.

(7) Exercise presently-assigned and proposed in S. 7 and H.R. 4148 (if enacted), regulatory authority in the following areas:

(a) Enforcement of water quality standards, as necessary, and various other controls over pollution including:

[1] Oil, thermal, and radioactive pollution;

[2] Disposal of vessel wastes;

[3] Disposal of solid wastes and other refuse, dredged fill, etc., in navigable waters;

[4] Treatment of wastes at Federal installations.

(b) Issuance of permits, licenses, or other controls governing certain permissible uses or modification of estuarine and coastal resources including:

[1] Permits for structures over and in navigable waters;

[2] Regulations establishing harbor lines;

[3] Regulations restricting use of navigable waters for various purposes (danger zones, fishing grounds, etc.); and

[4] Licenses regulating the construction and operation of non-Federal hydroelectric and nuclear facilities for generating electric power.

(8) Coordinate Federal estuarine and coastal management activities and provide means for coordinating these activities with those of the States, and their subdivisions, and interstate agencies.

(9) In cooperation with the States, continuously monitor developments and conditions in estuaries and coastal areas and evaluate the effectiveness of the national program.

(10) Provide adequate investigation and consideration for the protection of estuarine values in the formulation of comprehensive river basin development programs under the aegis of the Water Resources Council by assuring cooperative State-Federal recognition of the impacts of upstream water quality and hydrology and related land resources development upon the resources of the estuaries.

Before leaving the recommended Federal role it is important to note that several of the above items are already the subject of legislation currently being considered by Congress.

RECOMMENDATIONS CONCERNING NEW LEGISLATION AT THE FEDERAL LEVEL

If the Federal role in the National Estuarine and Coastal Zone Management Program is to be carried out successfully, critical needs are new legislation authorizing a Federal program directed specifically to the problems of the estuarine and coastal zone and provisions for coordination of that new program with existing programs directly or indirectly affecting those zones.

Accordingly, it is first recommended that there be: The enactment of legislation establishing the comprehensive national management program. Among its purposes, this legislation should:

(1) Specify the national policy, its broad objectives and guidelines.

(2) Establish and fund two new programs of grants as follows:

(a) Matching program development grants to a State for the purpose of assisting the State in preparing a comprehensive State program for the management of its estuarine and coastal zones. To be eligible for such grants the State must demonstrate that the grant will be used to develop a comprehensive management program meeting the requirements set forth in the following section on operating grants.

(b) Upon approval of the State's comprehensive management program, annual operating grants to the State to assist in the administration of the State program for comprehensive management of its estuarine and coastal zones.

In the administration of such operating grants it shall be ensured that: The Coastal State is organized to implement the comprehensive management plan.

It shall also be ensured that the State has at least certain specific authorities as follow:

[1] Permit authority to control dredge, fill, and alteration of the lands and waters below the mean highwater marks.

[2] Zoning authority, or authority to require local zoning to conform with the State management plan.

[3] The power of eminent domain as necessary for implementation of the plan.

The comprehensive plan of management shall be consistent with the policy and objectives of the national estuarine and coastal zone management program and shall include the following:

[1] A feasible land and water use plan consistent with existing water quality standards.

[2] Recognition of the national interests and State and local interests in the preservation, use, and development of the estuarine and coastal zone.

[3] Appropriate consideration of other resources use and management plans bearing on the use, conservation, and management of the estuarine and coastal zones.

The plan should be adopted only after public hearings and consultation with all appropriate interested parties and shall contain in addition to the above the following:

[1] A description of the coastal State's current programs.

[2] A program for regular review and updating of the management plan, with procedures for modification of it that include public hearings.

[3] Provision for adequate review of State, local, and private projects for consistency with the plan and for advice regarding the consistency of Federal and federally assisted projects with the plan.

[4] An identification of the boundaries of the portions of the coastal State subject to the management plan.

(c) With the approval of the Secretary, the Governors of the respective States may designate an existing interstate agency to receive a portion of both the planning and operating grant to the individual States.

(d) Provide that operating grant support shall be withdrawn when there is failure to adhere to a comprehensive plan of management.

(3) Authorize the Secretary of the Interior to:

(a) Administer the proposed new program of Federal grants to States and interstate agencies.

(b) Develop after appropriate consultation and review the necessary rules and regulations needed to administer the proposed new program.

(c) Conduct a continuing review of State programs for the development, conservation, and use of the Nation's estuaries and coastal areas.

(d) Establish advisory bodies in the Department of the Interior to advise, consult with, and make recommendations to the Secretary on matters of policy in the National Estuarine and Coastal Zone Management Program.

(e) Cooperate with other Federal departments concerned with the comprehensive management of the estuarine and coastal zone and to establish the mechanisms necessary for such cooperation.

(f) The Secretary should not approve State plans until he has solicited the views of Federal agencies principally affected by such plans or has evidence that such views were provided the State in the development of the plan.

(4) All Federal agencies conducting or supporting activities in the coastal area should seek to make such activities

consistent with the approved plan for the area. States and local governments submitting applications for Federal assistance in coastal areas should indicate the views of the appropriate State or local agency as to the relationship of such activities to the approved plan for the coastal area. Federal agencies should not approve proposed projects that are inconsistent with the plan without making investigation and finding that the proposal is, on balance, sound. The Secretary should be advised by the heads of other agencies of such problems and be provided an opportunity to participate in any investigation.

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As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park, and recreational resources. Indian and Territorial affairs are other major concerns of America's "Department of Natural Resources."

The Department works to assure the wisest choice in managing all our resources so each will make its full contribution to a better United States — now and in the future.